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Remedial Design Report and Remedial Action Work Plan for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' Interim Action

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ABBREVIATIONS AND ACRONYMS

ARAR	applicable or relevant and appropriate requirement
BHI	Bechtel Hanford, Inc.
CERCLA	*Comprehensive Environmental Response, Compensation, and Liability Act of 1980*
CHI	CH2M HILL Hanford, Inc.
DOE	U.S. Department of Energy
DOE-RL	U.S. Department of Energy, Richland Operations Office
Ecology	Washington State Department of Ecology
EDPI	Engineering Department Project Instruction
EPA	U.S. Environmental Protection Agency
ERC	Environmental Restoration Contractor
ERDF	Environmental Restoration Disposal Facility
FY	fiscal year
GTS	groundwater treatment system
HDPE	high-density polyethylene
NCP	*National Oil and Hazardous Substance Pollution Contingency Plan*
NPL	National Priorities List
OIC	operator interface computer
PLC	programmable logic controller
RAWP	remedial action work plan
RDR	remedial design report
ROD	record of decision
RDR/RAWP	remedial design report/remedial action work plan
TCLP	toxicity characteristic leaching procedure
WAC	*Washington Administrative Code*

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EXECUTIVE SUMMARY

This document is a combination remedial design report and remedial action work plan for the 100-HR-3 and 100-KR-4 Operable Units' interim action. The interim action described in this document represents the first phase of an ongoing program to address groundwater contamination in each operable unit. Preparation of this document is required by the interim action record of decision (interim action ROD) issued in April 1996 by the U.S. Environmental Protection Agency and the Washington State Department of Ecology. This document describes the design basis, provides a description of the interim action, and identifies how they will meet the requirements set forth in the interim action ROD.

The first phase of the 100-HR-3 and 100-KR-4 interim action consists of a pump-and-treat remediation alternative that extracts groundwater containing hexavalent chromium from target areas in each operable unit, and evaluating data from the operable units to help determine if adjustments to the interim action target areas are needed. The target areas were identified using recent water quality data obtained from monitoring well groundwater and river substrate pore water samples. Extracted groundwater will be treated using an ion-exchange treatment process to remove hexavalent chromium and the treated groundwater returned to the aquifer using injection wells.

The 100-HR-3 pump-and-treat system consists of five extraction and three injection wells located in the 100-H Area, and two extraction wells located in the 100-D Area. Groundwater extracted from the 100-D Area will be conveyed by an aboveground pipeline to the 100-H Area for treatment and injection into the aquifer. Initial groundwater extraction rates in the 100-H Area range from 38 to 150 L/min (10 to 40 gal/min) and 150 L/min (40 gal/min) each for the two 100-D Area extraction wells. Initial injection rates of 320 L/min (85 gal/min) are planned for two of the injection wells, with the third well serving as a backup well in the event that maintenance is required or additional capacity is desired.

The 100-KR-4 pump-and-treat system consists of six extraction and four injection wells. Initial groundwater extraction rates for each of the six wells are 95 L/min (25 gal/min), and 190 L/min (50 gal/min) for three of the injection wells. The fourth injection well will serve as a backup well.

The 100-HR-3 and 100-KR-4 groundwater treatment systems will consist of modular 380-L/min (100-gal/min) ion-exchange columns filled with a strong or intermediate-base resin. The 100-HR-3 treatment system will have four 380-L/min (100-gal/min) trains with four columns connected in series for each train. The 100-KR-4 treatment system will have two 380-L/min (100-gal/min) column trains. Various ion-exchange resins are being considered for use in the systems. The concurrence of the regulatory agencies will be sought when resins are initially identified for use.

The 100-HR-3 and 100-KR-4 pump-and-treat interim actions were designed to achieve three remedial action objectives described in the interim action ROD. The three remedial action objectives include the following:

- Protection of aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River
- Protection of human health by preventing exposure to contaminants in the groundwater
- Provide information that will lead to the final remedy.

Specific information on how each of the remedial action objectives will be met and where the information is discussed in this document is provided in Table ES-1. The interim action ROD also describes other requirements that were factored into the design, construction, and operation of the pump-and-treat systems. These requirements are also summarized in Table ES-1.

Construction of the pump-and-treat systems will be performed by a subcontractor with oversight provided by the Environmental Restoration Contractor design and construction management team. Once construction activities are completed, the system will undergo a comprehensive functional test and readiness evaluation prior to a phased startup.

The effectiveness of the pump-and-treat system will be assessed based on monitoring data collected over the lifetime of the interim action. The interim action monitoring program will include water level measurements, analysis of water quality samples for hexavalent chromium and co-contaminants, and measurements of specific conductance. These data will be collected over an 8- to 12-month prestartup period to document baseline conditions, during a 3-month startup period when timely information is necessary to adjust system operation, and during the operational phase to track progress towards achieving the remedial action objectives.

The timeframe for operation of the interim actions has not been estimated. Termination of the interim actions is anticipated once the 22-µg/L protective level, or regulatory agency approved alternate concentration level, is permanently achieved in each of the extraction and compliance monitoring wells present in the target areas, or a final remedy is selected.

Table ES-1. Interim Action Design and Performance Criteria Required by the Interim Action Record of Decision. (sheet 1 of 5)

Number	Requirement	ROD Section	How Met	RDR/RAWP Section
Remedial Action Objectives				
1	Protection of aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River	VII	Extraction and treatment of groundwater to remove chromium	3.1 to 3.4 and 5.1.1
2	Protection of human health by preventing exposure to contaminants in the groundwater	VII	Institutional controls and groundwater use notification	5.1.2
3	Provide information that will lead to the final remedy	VII	Monitoring and reporting of treatment costs, system efficiency, hydraulic impacts, and effectiveness of contaminant removal	5.1.3
Design, Construction, and Performance Criteria				
4	Placement of groundwater extraction wells	X, pg 42	Use of numerical modeling to optimize well locations with Cultural Resource concurrence	3.2 and Appendix B
5	Treatment of groundwater to the maximum extent practicable. No chromium discharge above 50 µg/L	X, pg 42	Testing to determine the level of treatment technically feasible, monitoring to ensure the 50-µg/L level is not exceeded	5.3.1
6	Treatment of groundwater to remove other contaminants	X, pg 42	Some resins being considered are capable of partially removing co-contaminants	5.2.2
7	Reinjection of treated groundwater using injection wells located upgradient of extraction wells	X, pg 43	Available Hanford Environmental Information System data and numerical modeling used to optimize location of injection area	3.3.1.3 and 3.3.2.3
8	Compliance Monitoring-River Protection			
	a. Procedures to evaluate compliance	X, pg 43	Approach described	5.1 to 5.3
	b. Sampling conducted when dilution by river water is minimal	X, pg 44	Approach and schedule to be developed using historical and prestartup data	5.2.2
	c. Sampling at multiple depth intervals	X, pg 44	Multilevel sampling in new monitoring wells and sampling of existing nested wells	5.2.4
	d. Monthly sampling for 3 months following startup	X, pg 44	Monthly sampling for first 3 months will be performed	5.2.3 and Table 5-1
	e. Network of piezometers, or comparable techniques to be installed and monitored for mapping capture zone extent	X, pg 44	Existing and new wells to be used for transducer-performed water-level measurements	5.2.1

Table ES-1. Interim Action Design and Performance Criteria Required by the Interim Action Record of Decision. (sheet 2 of 5)

Number	Requirement	ROD Section	How Met	RDR/RAWP Section
	f. The analyte list shall include hexavalent chromium (or total chromium assumed to be hexavalent), conductivity, or comparable measurements to indicate ratio of river-derived water versus groundwater, on an infrequent basis co-contaminants	X, pg 44	Hexavalent chromium, specific conductance, and co-contaminants will be measured during the interim action	5.2.2 and Table 5-1
9.	Compliance Monitoring-Effluent for Reinjection			
	The data analysis and evaluation procedures used to evaluate compliance with the cleanup level shall be defined in the RDR/RAWP and prepared using *Washington Administrative Code* (WAC) 173-340-720(8) and approved by EPA and Ecology	X, pg 44	Compliance with the 50-µg/L injection standard will initially be performed using weekly grab samples and, eventually, a continuous inline chromium monitor	5.2.3 and Table 5-1
10.	Construction Requirements shall be scoped as part of the RDR/RAWP with guidance from EPA and Ecology. The work plan shall include the following elements:			
	a. Construction is expected to comply with appropriate worker safety requirements	X, pg 44-45	A contractor-prepared and Environmental Restoration Contractor-prepared construction health and safety plan will be prepared during the implementation phase	3.1.3
	b. In coordination with wildlife and other resource management agencies, activities should avoid or minimize disruption to local wildlife and other natural resources to the extent practicable		The design team actively involved other affected and interested parties in the design and location of interim action activities	Appendix A
	c. Design should provide for flexibility following startup to accommodate changes in plume characteristics, or different understandings of actual or perceived responses of the aquifer/plume to the pump-and-treat system		Adjustable-frequency drive pumps provide for flexible pumping rates; compliance monitoring wells can be connected to provide additional pumping capability; the treatment system has extra capacity	3.2 to 3.4

Table ES-1. Interim Action Design and Performance Criteria Required by the Interim Action Record of Decision. (sheet 3 of 5)

Number	Requirement	ROD Section	How Met	RDR/RAWP Section
	d. For areas that are disturbed during construction and operation, it is expected that the land will be revegetated during construction in those areas not needed for operation and maintenance		A mitigation action plan describing revegetation activities will be prepared during the interim action implementation phase	
	e. To the extent practicable, facilities are expected to be designed and located in a manner that minimizes interference with and interference by remedial actions for the source waste sites		The design team consulted with source operable unit teams to identify areas where potential conflict(s) may occur	
	f. Sites with cultural resource significance should be avoided during remedial design activities if avoidance is possible. Where avoidance is not possible, a data recovery/mitigation plan must be prepared in consultation with the affected resource trustee		A mitigation action plan describing revegetation activities will be prepared during the interim action implementation phase	
11.	Schedule			
	a. Draft A of the RDR/RAWP is due to EPA/Ecology within 120 days after the ROD is signed	X, pg 45	The RDR/RAWP will be submitted within 120 days	Figure 6-1
	b. Phase 1. Two pump-and-treat systems are to be operating within 15 months of the ROD signing		100-HR-3 startup planned for July 1997	Figure 6-1
	c. Phase 2. The third pump-and-treat system shall be operating within 18 months of the ROD signing		100-KR-4 startup planned for October 1997	Figure 6-1
12	Resin Disposal			
	Wastes generated during the remedial action, principally exhausted resins, will be disposed at the Environmental Restoration Disposal Facility, or at other onsite facilities as appropriate	X, pg 46	An operations waste management plan will be developed. If spent resin exceeds toxic characteristic leaching procedure-Cr reference levels, stabilization or alternate disposal options will be determined	Waste Management Plan (Appendix D)
13	Human Access Institutional Controls			
	a. The DOE is responsible for establishing and maintaining land use and access restrictions until maximum contaminant levels and risk-based criteria are met, or the final remedy is selected	X, pg 46	Maintain institutional controls, maintain signs along river bank, modify existing groundwater use notification	5.1.2

Table ES-1. Interim Action Design and Performance Criteria Required by the Interim Action Record of Decision. (sheet 4 of 5)

Number	Requirement	ROD Section	How Met	RDR/RAWP Section
	b. DOE shall provide EPA and Ecology with written verification that these restrictions have been put in place	X, pg 46	Access controls will be inspected and documented in the facility operating record. A copy of groundwater use notification will be provided	5.1.2
14	Up-Time Requirements			
	a. The extraction and treatment system shall run on an essentially continuous basis so that resin changes and maintenance can be performed with minimal impact to system operations	X, pg 46	The system has been designed to run on an essentially continuous basis	5.3.2
	b. The system should be winterized so that winter does not cause extended shutdowns	X, pg 46	Exposed polyvinyl chloride piping and tanks are heat traced. Buildings are insulated. High-density polyethylene conveyance piping not susceptible to freezing while in operation	3.4.5
	c. The system shall be designed such that if one or several of the wells are down, the rest of the system can continue operating	X, pg 46	Extraction wells are generally on separate conveyance laterals allowing for independent operation	3.4.1, 3.4.3, Figures 3-9a, 3-9b, and 3-9c
15	Investigation-Derived Waste	X, pg 47	Wastes will be disposed in accordance with the ROD	Waste Management Plan (Appendix D)
16	Impacts to *Resource Conservation and Recovery Act* Monitoring	X, pg 47	Shared monitoring responsibilities to be developed	Performance Monitoring Plan
17	Operational Requirements			
	a. The pump-and-treat portion of the interim action will continue until selection of the final action	X, pg 47	Monitoring of interim action progress until such time that preparation of a Cumulative Risk Assessment is warranted	5.4.3
	b. It is demonstrated that hexavalent chromium is below the compliance value	X, pg 47	Calculation of an upper confidence interval using 1 year's worth of monitoring data following shutdown of the extraction system	5.4.1
	c. The effectiveness of the treatment technology does not justify further operation	X, pg 47	Treatment system no longer provides significant reduction in chromium concentration, or no longer cost effective	5.4.2.2
	d. An alternative treatment technology is proved to be more effective	X, pg 47	Alternative treatment technologies are being evaluated under the various programs	5.4.2.2

Table ES-1. Interim Action Design and Performance Criteria Required by the Interim Action Record of Decision. (sheet 5 of 5)

Number	Requirement	ROD Section	How Met	RDR/RAWP Section
18	Wetlands and Floodplains	X, pg 47	Only activity to be conducted in floodplains is the potential use of drive points that were initially selected because of their minimal impact	A1.4 (Appendix A)
19	Protectiveness			
	The interim action is expected to provide protection of human health and the ecological receptors in the Columbia River until implementation of the final remedy, or until such time that DOE demonstrates that no further interim action is required	X, pg 47-48	Monitoring of the interim action and reporting on its effectiveness will be used to demonstrate the protectiveness of the interim action	5.3 and 5.5

DOE = U.S. Department of Energy
Ecology = Washington State Department of Ecology
EPA = U.S. Environmental Protection Agency
RDR/RAWP = remedial design report/remedial action work plan
ROD = record of decision

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1.0 INTRODUCTION

This document presents both the remedial design report and remedial action work plan (RDR/RAWP) for the 100-HR-3 and 100-KR-4 Groundwater Operable Units' interim action as stipulated in the *Record of Decision for the 100-HR-3 and 100-KR-4 Operable Units* (EPA 1996). This document was prepared to fulfill the requirements for an RDR/RAWP as described in Section X of the interim record of decision (ROD) (EPA 1996).

1.1 BACKGROUND

The Hanford Site is a 1,450-km^2 (560-mi^2) federal facility located along the Columbia River near Richland, Washington. From 1943 to 1990, the primary mission of the Hanford Site was the production of nuclear materials for the Nation's defense. In November 1989, this mission was expanded when the Hanford Site was placed on the National Priorities List (NPL) under the *Comprehensive Environmental Response, Compensation, and Liability Act of 1980* (CERCLA) as amended by the *Superfund Amendments and Reauthorization Act of 1986*. Four areas of the Hanford Site were identified for NPL listing: the 100 Area, the 200 Area, the 300 Area, and the 1100 Area. The 100 Area, which encompasses approximately 68 km^2 (26 mi^2) bordering the southern shore of the Columbia River, is the site of six reactor areas (100-B/C, 100-D/DR, 100-F, 100-H, 100-KE/KW, and 100-N). Several operable units, in various stages of the CERCLA investigation and remediation process, are located within each reactor area. This document addresses interim remedial actions planned for the 100-HR-3 and 100-KR-4 Operable Units, located within the 100-D/DR, 100-H, and 100-KE/KW Reactor areas.

The 100-HR-3 Operable Unit (Figure 1-1) is located in the north-central part of the Hanford Site along a section of the Columbia River known as the "Hanford Reach." This operable unit includes the groundwater underlying other operable units associated with the 100-D/DR and 100-H Reactor areas and the 600 Area in between.

The 100-KR-4 Operable Unit (Figure 1-2) is also located along the Columbia River, several miles southwest of 100-HR-3. The 100-KR-4 Operable Unit is one of three operable units associated with the 100-K Area and includes the groundwater underlying the 100-KR-1 and 100-KR-2 Operable Units.

1.2 PURPOSE AND OBJECTIVES OF INTERIM ACTION

The primary purpose of this interim action is to address contaminated areas that pose threats to human health or the environment. There are no current unacceptable human health risks from contaminants in the groundwater, primarily because exposure is precluded by U.S. Department of Energy (DOE) site controls. However, a qualitative ecological risk assessment concluded that hexavalent chromium concentrations in groundwater exceed the U.S. Environmental Protection

Agency's (EPA) Ambient Water Quality Criteria of 11 µg/L for protection of freshwater aquatic life. Therefore, this interim action is necessary to protect ecological receptors along the Hanford Reach of the Columbia River, where groundwater discharges from the 100-HR-3 and 100-KR-4 Groundwater Operable Units. Of particular concern is the potential for chromium-bearing groundwater to enter pore water in the gravel river-bottom habitat used by salmon eggs, alevin, and fry (DOE-RL 1995c, 1995d).

The interim action to be implemented involves pumping groundwater from selected well locations in each operable unit and treating that water to remove chromium prior to injection back into the aquifer. This interim action will achieve three remedial action objectives identified in the interim action ROD: (1) protection of aquatic receptors in the river bottom substrate from contaminants in groundwater entering the Columbia River, (2) protection of human health by preventing exposure to contaminants in the groundwater, and (3) provide information that will lead to the final remedy. The way in which this interim action addresses each of these objectives is detailed in Chapter 5.0 of this document.

1.3 ROLES AND RESPONSIBILITIES

Design and implementation of the 100-HR-3 and 100-KR-4 interim action will require the cooperative effort of a multidiscipline project team. This team includes representatives from the DOE, Richland Operations Office (DOE-RL), the DOE-RL's Environmental Restoration Contractor (ERC), and the regulatory agencies: the EPA and the Washington State Department of Ecology (Ecology). The role and responsibilities of each team member are described in the following subsections.

1.3.1 U.S. Department of Energy, Richland Operations Office

The DOE-RL is the government agency responsible for remedial actions throughout the 100 Area. The DOE-RL has assigned a project manager for the 100-HR-3 and 100-KR-4 interim action who will be responsible for approval of project scope, technical oversight, funding, and scheduling activities and acting as the regulatory agency interface.

1.3.2 Environmental Restoration Contractor

Bechtel Hanford, Inc. (BHI) and its preselected subcontractors, CH2M HILL Hanford, Inc. (CHI) and IT Hanford, Inc., are responsible for providing services required for design engineering, construction management, and the operation and monitoring of the interim action. BHI's project engineer and CHI's project manager are responsible for determining the scope of work and the budget and schedules necessary to support interim action design and implementation. These individuals are the primary points-of-contact for execution of the work. BHI's task lead is the primary interface between the project team and DOE-RL.

1.3.3 Regulatory Agency

The regulatory agency team includes representatives from EPA and Ecology. Ecology is the lead regulatory agency for 100-HR-3 and EPA is the lead agency for 100-KR-4. However, both agencies are expected to support and participate in project decision making and to approve agency-required documents.

1.4 CONTENT AND ORGANIZATION OF THE RDR/RAWP

This RDR/RAWP combines the requirements of a remedial design report (RDR) and remedial action work plan (RAWP) into a single document. The purpose of the RDR, presented in Chapters 2.0 and 3.0 of this document, is to describe the criteria used to develop the remedial design and summarize the remedial action method. The purpose of the RAWP, presented in Chapters 4.0, 5.0, and 6.0 of this document, is to describe how the remedial action will be implemented and what approach will be used to determine its effectiveness. The remedial action to be implemented at the 100-HR-3 and 100-KR-4 Operable Units is pump and treat. This action was recommended in the focused feasibility study reports (DOE-RL 1995a, 1995b) and specified in the interim action ROD. This pump-and-treat action is an interim action designed to mitigate immediate risks to the environment.

The most important design consideration, and the one with the greatest element of uncertainty affecting the remedial design, is the horizontal and vertical distribution of chromium in each of the two operable units. Contained in Chapter 2.0 of this document is a comprehensive summary of hydrogeologic and recent water quality information used to develop an updated conceptual model for each of the three sites. The updated conceptual models were used to identify the target area for each interim action.

From the updated conceptual models, the design integrated other hydraulic, treatment, and operational criteria to develop the overall remedial design. Chapter 3.0 and Appendices A through C describe the approach used by the design team to select the location and pumping rates for the groundwater extraction and injection wells. Treatment system resin type and the operational philosophy that influenced selection of many of the system's components are also included. In addition, Chapter 3.0 identifies potential uncertainties that may impact remedial action performance and describes contingency actions that may be implemented to manage them.

Implementation of the remedial action will be performed with the assistance of one or more prequalified subcontractors. Contained in Chapter 4.0 is a general summary of the approach that will be used after the subcontractor has been selected to construct, test, and start up the pump-and-treat system. Chapter 6.0 provides an engineering estimate for the sequence and duration of each implementation activity.

Monitoring the remedial action will be necessary to demonstrate its effectiveness and to collect information necessary to satisfy the remedial action objectives and performance criteria specified in the interim action ROD. Therefore, Chapter 5.0 reiterates the remedial action objectives and performance criteria contained in the interim action ROD and describes the proposed approach for achieving them.

Figure 1-1. 100-HR-3 Operable Unit.

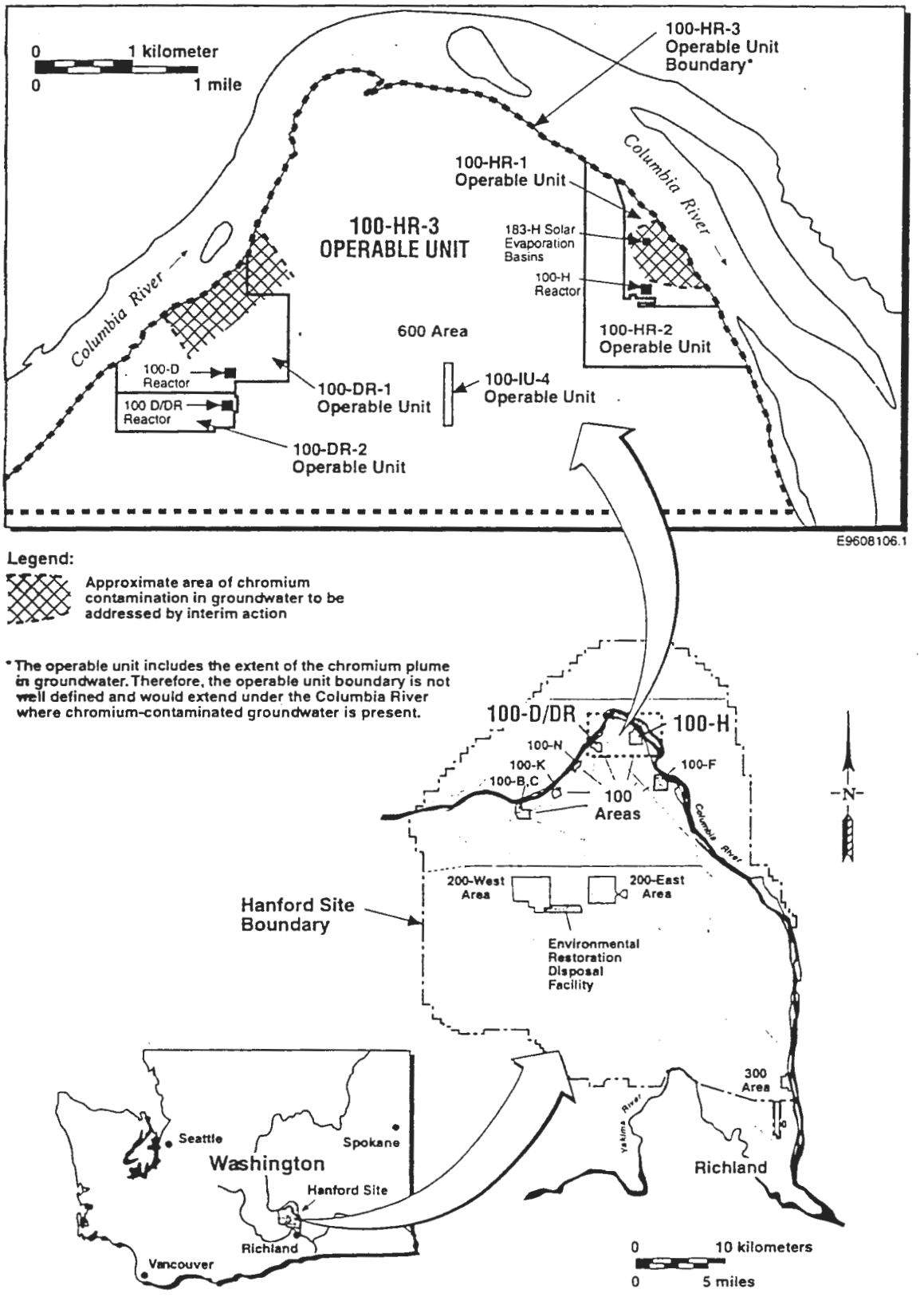
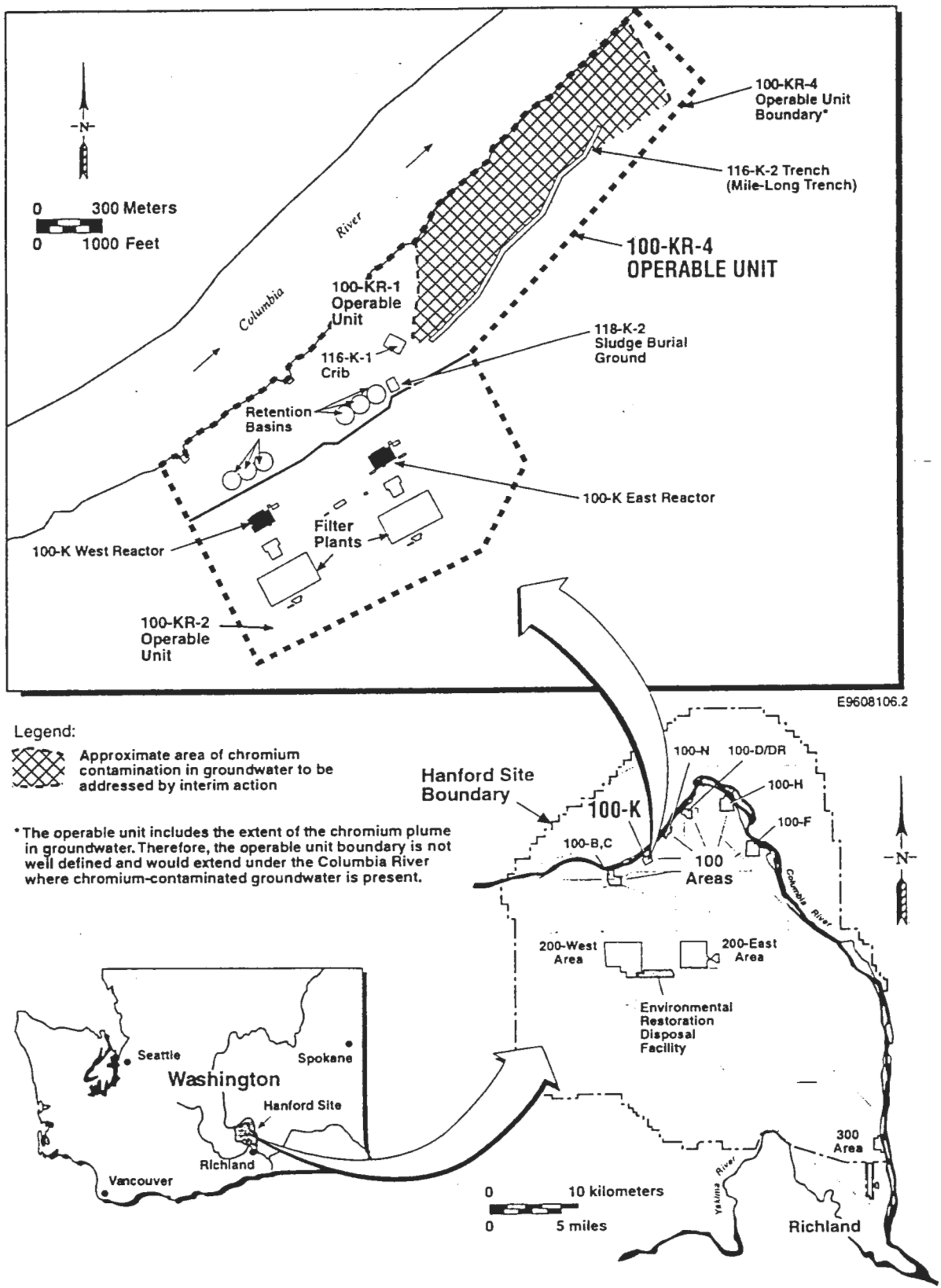


Figure 1-2. 100-KR-4 Operable Unit.



2.0 CONCEPTUAL MODELS FOR INTERIM ACTION DESIGN

2.1 INTRODUCTION OF CHROMIUM TO GROUNDWATER AT THE 100-H, 100-D, AND 100-K AREAS

Limited field investigations and qualitative risk assessments performed for the 100-HR-3 and 100-KR-4 Operable Units established that hexavalent chromium is a groundwater contaminant of concern for ecological receptors in the river (DOE-RL 1993, 1994). The mobility of chromium in groundwater varies with the valence of the cation. Chromium III readily adsorbs to soil particles and is considered insoluble and immobile in groundwater with pH greater than 6.0 (Davis et al. 1993). Chromium VI (hexavalent) is highly mobile and is more toxic to aquatic organisms than the trivalent form. For convenience, hexavalent chromium is simply referred to as "chromium" in the text unless noted otherwise.

Chromium was introduced to the soil and groundwater from a number of sources and at varying concentrations (Carpenter 1993, Carpenter and Coté 1994, DeFord and Einan 1995). The most widespread chromium plumes were introduced by reactor coolant water that contained chromium. Sodium dichromate was added to reactor cooling water as a corrosion inhibitor at a concentration of 2 mg/L, which dissociates to an initial, maximum chromium concentration of 700 µg/L. The throughput of the single-pass reactor cooling systems was huge, e.g., the 100-H Reactor passed an estimated 174,000 to 268,000 L/min (46,000 to 71,000 gal/min) of coolant. After passing through the reactor, the coolant flowed through large-diameter underground piping to retention basins for thermal and radioactive cooling prior to discharge to the Columbia River. When fuel cladding ruptures occurred, trenches and cribs were used to dispose of the radiologically contaminated cooling water. Coolant system piping and retention basins leaked large volumes to the ground (Ryan 1963). This created substantial groundwater mounds and raised the water table over large portions of each reactor area. For example, the 100-D Area mound was 3 to 6 m (10 to 20 ft) higher than the ambient water table (Brown 1963). These mounds dissipated following cessation of reactor operations.

Higher concentrations of chromium (greater than 700 µg/L) were also introduced to the soil column and migrated down to groundwater in more localized areas. Leaks and spills of concentrated sodium dichromate stock solutions likely occurred where it was stored and handled. Chromic acid was used to decontaminate reactor equipment, and was then disposed to french drains, cribs, and trenches.

Some chromium may remain in solution in the capillary fringe above the water table and in the residual soil moisture of the vadose zone. However, there are no observational data to verify this condition. If present in the soil column, chromium may continue to enter groundwater as the water table fluctuates and with soil moisture that moves downward to recharge the unconfined aquifer. Average natural recharge by infiltrating precipitation is generally less than 5 to 20 mm/yr in the 100-H, 100-D, and 100-K Areas, depending on local soil composition and vegetative cover (Fayer and Walters 1995). Interpretations of groundwater monitoring data

should consider this mode of chromium introduction, particularly where isolated, high chromium concentrations are detected or if chromium concentrations increase following high water table events.

Conceptual models were developed for the 100-H and 100-D Areas (100-HR-3 Operable Unit) and vicinity of the 116-K-2 Trench in the 100-KR-4 Operable Unit. Elements of the conceptual model for each area include the following:

- Sources of chromium in groundwater
- Chromium plume distribution
- Geology and stratigraphy
- Hydrogeology.

These conceptual model elements provide remediation system designers with information on the introduction of chromium to groundwater, geographic extent of contamination, its movement characteristics, and the dimensions of the geologic framework through which it moves. This information is used to layout extraction and injection well networks, define construction details for new wells, and provide a basis to optimize the location and number of wells through numerical modeling.

A second purpose of the conceptual models is to provide a basis for evaluating the performance of the remediation system. This includes identifying locations for observing the effects of the extraction network on the water table and plume concentration changes. After the extraction network has operated for a period of time, its effect on the aquifer and chromium plume will be better defined. The approach for monitoring the performance of the extraction network is discussed in Chapter 5.0. Relevant elements of the conceptual models and monitoring requirements will also be presented in a performance monitoring plan for the interim action.

Data on chromium distribution and groundwater flow have been extracted from the Hanford Environmental Information System. Post-processing includes several steps to enhance utility of the data set and to correct known problems. Data representing the time interval between January 1994 and August 1995, which covers slightly more than a complete seasonal cycle of hydrologic conditions, were used to develop the conceptual models for each site. At the time that design was initiated, this was the most recent data set available. More recent data from monitoring and river shoreline and substrate investigations have been incorporated as practical. Geologic information has been extracted from geologist and driller logs for monitoring wells and as described in various characterization reports.

2.2 100-H AREA CONCEPTUAL MODEL FOR CHROMIUM

This section describes the conceptual model for chromium in the 100-H Area to be addressed by the interim action.

2.2.1 100-H Area Sources for Chromium Contamination in Groundwater

Past sources of chromium in groundwater are from leakage or disposal of chromium-laden liquids to the soil column by reactor and waste management activities within the 100-H Area (DeFord and Einan 1995). Chromium is also attributed to leakage from the 183-H Solar Evaporation Basins (Peterson 1994) and the 107-H Retention Basins. Other sources are those waste disposal sites near the reactor building that received decontamination solids and process effluents.

Another source of chromium in the 100-H Area is now attributed to a large chromium plume from the 100-D Area. During the years of reactor operations, a significant groundwater mound developed under the 107-D Retention Basins and a chromium plume spread outward (Brown 1963, Connelly 1996). The plume migrated to the east and northeast from the 100-D Area and discharges to the Columbia River in the vicinity of the 100-H Area.

2.2.2 100-H Area Chromium Plume Distribution

The distribution of chromium in 100-H Area groundwater is shown in Figure 2-1. The concentrations in Figure 2-1 are based on average chromium concentrations for the period January 1, 1994 to August 30, 1995. Chromium contributions from local 100-H Area sources have likely dispersed by now, and the relatively high-concentration core of the plume formerly present has presumably moved to the Columbia River. Wells 699-96-43 and 699-97-43, located upgradient along flow lines leading to the 100-H Area, provide evidence that a chromium plume is migrating into the 100-H Area from the 100-D Area. Open contours in Figure 2-1 are used to depict the incoming chromium plume from the 100-D Area.

The concentrations of chromium measured in 100-H Area wells are listed in Table 2-1. Groundwater generally flows eastward to the river. Chromium concentrations in near-river wells vary considerably in response to river level changes. The influx of river water to the aquifer during high river stages causes concentrations to decrease markedly in some near-river wells.

The discharge of chromium-contaminated groundwater to the Columbia River was verified by riverbank seepage data (Peterson and Johnson 1992). The presence of chromium contamination in the riverbed was verified by analysis of pore water samples collected along the 100-H Area shoreline (Hope and Peterson 1996a). The results are shown in Figure 2-2. Chromium concentrations of 52 to 130 µg/L were measured in riverbed substrate samples collected at sampling station 1. Chromium (73 µg/L) was also measured in the riverbed substrate farther upstream at sampling station 14, but was not detected or did not exceed 11 µg/L at other sampling stations. The quantitative relationship between chromium concentrations detected in the riverbed substrate and the concentrations of chromium measured in near-river wells is highly variable.

Data on the vertical distribution of chromium in groundwater are limited. Three cluster well sites, each with three wells completed at varying depths, are located in the vicinity of the

chromium contamination targeted by the interim action. These well clusters are H3-2A, H3-2B, and H3-2C; H4-12A, H4-12B, and H4-12C; and H4-15A, H4-15B, and H4-15C (see Figure 2-1). The "A" wells are completed in the uppermost portion of the unconfined aquifer, and the "B" wells are completed at a lower depth in the unconfined aquifer. The "C" wells are completed at a greater depth in a semi-confined zone below the "B" wells (Figures 2-3 and 2-4). Well H4-12C contains anomalously high concentrations of chromium, which have remained at approximately 275 µg/L for an extended period (data from "C" wells are not contoured in Figure 2-1). The cause of the anomaly remains uncertain. Monitoring of these deeper wells during the interim action will be useful to determine whether pumping the upper zone of the unconfined aquifer has an effect on chromium detected in well H4-12C.

Co-contaminants of interest within the chromium plume are nitrate and four radionuclides as indicated by gross alpha and gross beta measurements. Specific isotopes identified are tritium, strontium-90, uranium-238 (inferred from chemical and alpha measurements), and technetium-99. These co-contaminants are at relatively low chemical concentrations and radioactivity levels. Nitrate and tritium are associated with upgradient wells and the encroaching 100-D Area plume. The uranium and technetium are associated with wells in the vicinity of the 183-H Solar Evaporation Basins. Strontium-90 and other contaminants detected in well H4-11 may be associated with the 107-H Retention Basins.

2.2.3 100-H Area Geology and Stratigraphy

In the 100-H Area, the stratigraphic units relevant to interim action design and monitoring are the Hanford formation and upper mud unit of the Ringold Formation. Geologic cross sections showing data from monitoring wells are provided in Figures 2-3 and 2-4. Locations of the cross sections are depicted in Figure 2-1.

The Hanford formation overlies the Ringold upper mud unit and ranges in thickness from about 10 to 19 m (32 to 63 ft) from north to south, respectively (see Figure 2-4). Cataclysmic flood deposits, dominated by gravel with sandy interbeds, comprise the Hanford formation. Cobble-size clasts are common and boulders may be present. These clasts are predominantly derived from basalts. In some locations, the Hanford formation gravels are open framework and are not supported by a matrix of finer sediments (Lindsey and Jaeger 1993).

The contact between the Ringold Formation and the overlying Hanford formation is erosional and generally slopes from west to east. Of particular note is a narrow high or ridge-like feature in the Ringold Formation in the eastern part of the 100-H Area. The ridge is oriented approximately north to south, parallel to the river (see Figures 2-3 and 2-4), and is defined from the well logs for the numerous monitoring wells drilled in the vicinity of the 183-H Solar Evaporation Basins. The Hanford-Ringold contact may be similarly uneven where less geologic data exist. Differences in sediment size and clast composition usually distinguish the contact between the Ringold and Hanford Formations in the 100-H Area. However, rip-up clasts from the underlying Ringold Formation may be incorporated into the lower portion of the Hanford formation and can complicate identification of the contact.

Silt and clay-rich overbank-paleosol deposits dominate the upper 30 to 38 m (100 to 125 ft) of the Ringold Formation, which has a total thickness of about 80 m (265 ft) in the 100-H Area. These lithologic facies are referred to as the "Ringold upper mud unit." The Ringold upper mud contains few sand and gravel lenses and is commonly calcareous. The composition of these sands and gravels is predominantly felsic and quartzic minerals.

2.2.4 100-H Area Hydrogeology

For much of the 100-H Area, the water table is located about 9 to 27 m (30 to 50 ft) below the ground surface in the unconsolidated gravelly sediments of the Hanford formation. Groundwater generally flows toward the Columbia River (see Figure 2-1). During high river stage conditions, groundwater flows parallel to the river. The range and average water levels measured in 100-H wells and depth to water table from the top of the well casing are presented in Table 2-2. Because the water table fluctuates in response to river stage (Figure 2-5), extraction well pump output and efficiency may be influenced by river stage fluctuations. In addition, monitoring wells will be influenced by these changes in water level. The variability in aquifer response and plume concentrations caused by river stage fluctuations will be considered when evaluating the effectiveness of the pump-and-treat system.

The saturated thickness of the Hanford formation varies from about 0.8 to 6.4 m (2.6 to 21 ft) (Figure 2-6). Hydraulic conductivity for the Hanford formation ranges from about 15 to 1,050 m/day (50 to 3,445 ft/day) as determined by aquifer pumping tests, slug tests, and the Ferris method (Tyler 1996). The higher values may be attributed to open-framework gravels. The thinnest saturated portion of the Hanford formation is above the ridge in the Ringold Formation. This affects placement of extraction wells because of limited available drawdown. This "ridge" may enhance the performance of the remediation system by acting as a hydraulic barrier. Extraction wells placed on the downgradient side of the ridge will extract groundwater more influenced by near-river conditions. Extraction wells placed on the upgradient side of the ridge will enhance the performance of the near-river extraction wells by reducing the gradient and hydraulically expanding the capture zone of the near-river extraction wells. Wells pumped on the upgradient side of the ridge would also intercept the 100-D chromium plume and provide future protection of the river.

The Ringold upper mud unit is much less permeable and forms the base of the unconfined aquifer. There is a slight upward hydraulic gradient from the confined and semi-confined aquifers that underlie the unconfined aquifer. Laboratory analysis of the Ringold upper mud unit indicates that hydraulic conductivity is less than 0.01 m/day (Hartman and Peterson 1992), or 3 to 5 orders of magnitude lower than the overlying Hanford formation. Because of the marked difference in hydraulic conductivities of the two formations, chromium occurs primarily in the Hanford formation where it is most readily transported.

2.3 100-D AREA CONCEPTUAL MODEL FOR CHROMIUM

This section describes the conceptual model for chromium in the portion of the 100-D Area addressed by this interim action.

2.3.1 100-D Area Sources for Chromium in Groundwater

Multiple sources of chromium to groundwater via the soil column were present in the 100-D Area during reactor operations (Carpenter 1993). A principal source was coolant water disposed to the 107-D and 107-DR Retention Basins and associated Liquid Waste Disposal Trenches. The routine leakage of coolant water from the 107-D and 107-DR Retention Basins created significant groundwater mounds that altered the natural flow regime, enabling groundwater to flow south and east, opposite to the natural flow direction. Residual amounts of chromium from the former mounding may still be present in 100-D Area groundwater.

Other chromium sources include soil column disposal of decontamination solutions to small cribs and french drains located near the reactor buildings. Significant amounts of sodium dichromate were disposed to the fuel storage basin percolation trenches, located near the 105-D Reactor building. Finally, spillage/leakage of sodium dichromate stock solutions may have occurred in sufficient amounts to reach groundwater. These suspected spillage/leakage source areas are located immediately north of the 105-D Reactor, west of 105-D Reactor at the 190-D facilities, and southwest of the 105-D Reactor at a rail line transfer station.

2.3.2 100-D Area Chromium Plume Distribution

The distribution of chromium in the 100-D Area groundwater is shown in Figure 2-7. Chromium concentrations in Figure 2-7 are based on average chromium concentrations for the period January 1, 1994 to August 30, 1995. Chromium concentrations detected in relevant 100-D Area wells are listed in Table 2-3. In addition to chromium, co-contaminants of interest are nitrate, strontium-90, and tritium.

Groundwater flows to the northwest toward the Columbia River, to the north parallel to the river, and to the northeast toward the 100-H Area. Discharge of groundwater containing chromium to the river was confirmed by riverbank seepage sampling (Peterson and Johnson 1992).

In the fall of 1995, samples of river substrate pore water were collected by divers along the 100-D Area shoreline (Hope and Peterson 1996b). Sample locations were chosen to maximize the likelihood of collecting groundwater flowing into the river from the Hanford Site. In the target area of the interim action, the maximum observed concentration in river substrate pore water was 85 µg/L at sampling station 16. Although these results may not be representative of all areas adjacent to the 100-D Area where river substrate habitat might be exposed to chromium, the results do provide some direct evidence of exposure. Results of the sampling are shown in Figure 2-8. Higher concentrations of chromium have been detected in the riverbed pore water upstream along the 100-D Area. If it is determined that a significant plume exists contributing to

these higher concentrations in the river, the interim action target area may be expanded to address this plume.

In addition, chromium was detected in groundwater samples collected from multiple depths at shoreline sites adjacent to the river substrate sampling transects. Samples were collected from depths that approximated the substrate horizons where pore water samples were collected by divers. Higher concentrations were measured at a transect on the northwest corner of the 100-D Area where high concentrations of chromium were also measured in pore water samples. Results from this sampling are shown in Figure 2-9 and described in Hope and Peterson (1996b). An investigation to determine the probable source and extent of chromium contamination is under way at that location.

2.3.3 100-D Area Geology and Stratigraphy

In the 100-D Area, the stratigraphic units relevant to interim action design and monitoring are the Hanford formation, the Ringold Formation Unit E, and the Ringold Formation upper mud unit. Cross sections representative of the area are presented in Figures 2-10 and 2-11. Locations for these cross sections are shown in Figure 2-7.

The Hanford formation disconformably overlies either Ringold Formation Unit E gravels or the Ringold Formation upper mud unit in the 100-D Area (Lindsey and Jaeger 1993). The Hanford formation ranges in thickness from 13 to 30 m (44 to 100 ft), except in locations where it has been excavated or backfilled. The Hanford formation consists of cataclysmic flood deposits, dominated by gravel with sandy interbeds. Cobble-size clasts are common and boulders may be present.

Ringold Formation Unit E gravels are generally consolidated. Cementation may be locally well developed. This unit is as thick as 16 m (52 ft), but is completely absent in some locations. Where present, the top of the Ringold Formation Unit E gravels is at depths of 13 to 36 m (44 to 102 ft) below the ground surface. The distribution of Ringold Formation Unit E gravels is related to both Ringold depositional trends and post-Ringold Unit erosion. Along the northern and eastern boundaries of the area, Ringold Unit E gravels are absent and the upper mud unit is in contact with the Hanford formation.

The Ringold Formation upper mud unit consists of silt and clay-rich overbank paleosol deposits, with infrequent lenses of sand and gravel. In the area of the interim action, only well D8-54B fully penetrates the Ringold Formation upper mud unit. At this location, the Ringold Formation upper mud unit is 23 m (74 ft) thick. The top of the Ringold Formation upper mud unit is at depths of 18 to 32 m (59 to 104 ft) below the ground surface.

Of particular note is the apparent absence of the Ringold Formation Unit E gravels at near-river wells D8-54A (an extraction well), D8-54B, and D8-55, where the Hanford formation gravels are in contact with the Ringold upper mud unit. At well D8-53 (an extraction well), 115 m (377.3 ft) northeast of well D8-54A, the Ringold Formation Unit E gravels are present and in contact with

the Hanford formation gravels. A 6-m- (20-ft) thick portion of Ringold Formation Unit E gravels is present at well D8-2, approximately midway (80 m [260 ft]) between wells D8-55 and D8-54A. The Ringold Formation Unit E gravels are somewhat thinner along the near-river wells than wells inland.

2.3.4 100-D Area Hydrogeology

Groundwater flows to the northwest toward the Columbia River, to the north parallel to the river, and to the northeast toward the 100-H Area. For much of the 100-D Area, the water table is 15 to 27 m (50 to 90 ft) below ground surface. The water table fluctuates in response to river stage (see Figure 2-5 and Table 2-4). During high river stage conditions, groundwater flows to the northeast, parallel to the river. Because the water table fluctuates in response to river stage, extraction well pump output and efficiency may be influenced by river stage fluctuations. In addition, monitoring wells will be influenced by these changes in water level. Evaluation of the effectiveness of the interim action must consider potential variability in aquifer response and plume concentrations resulting from changes in river stage.

In the 100-D Area, the water table intersects both the Hanford formation gravels and Ringold Unit E gravels, due to the irregular contact between the two units. Hydraulic conductivity for the Hanford formation gravels is generally much higher than Ringold Unit E gravel. However, slug test data for the Ringold Unit E gravel unit screened at well D8-53 indicate that the hydraulic conductivity was higher than the nearby well D8-54A, which is screened in the Hanford formation. Slug tests for wells D8-54A and D8-53 resulted in estimated hydraulic conductivities of 122 and 162 m/day (400 and 530 ft/day). Because wells D8-53 and D8-54A appear to be screened in different formations, the aquifer response to pumping and resultant plume capture geometry may differ.

The Ringold upper mud unit generally forms the base for the unconfined aquifer and confines the aquifers below. The average saturated thickness for the aquifer above the upper mud unit is relatively thin and ranges from about 1.5 to 6 m (5 to 20 ft).

Cementation within the Ringold Unit E gravels is highly variable. The variations in permeability within the unconfined aquifer's sand and gravel units and irregular low-permeability base provided by the Ringold upper mud unit suggest that preferred flow paths for contaminant migration are likely. These preferred flow paths are not easily distinguished because of the relatively sparse coverage of monitoring wells in the 100-D Area. Along the river shoreline, it is plausible that those seeps that persist during long periods of low river stage may also be indicative of preferential pathways for chromium migration to the river.

2.4 100-K AREA CONCEPTUAL MODEL FOR CHROMIUM

The conceptual model for chromium distribution in groundwater for the vicinity of the 100-KR-4 interim action area is summarized in this section. Data for this area are more limited than for the other two reactor areas, so there is greater uncertainty associated with the conceptual model.

2.4.1 Sources of Chromium in Groundwater

Chromium was introduced to the soil and groundwater primarily by large discharges of chromium-contaminated reactor coolant water and other reactor effluents to the 116-K-2 Trench (Figure 2-12), which operated from 1955 to 1971. Other potentially significant chromium sources were the 116-K-1 Crib and retention basins. The 116-K-2 Trench is approximately 1,250 m (4,100 ft) long, 14 m (45 ft) wide, and 5 m (15 ft) deep, in its original configuration. The trench is situated above a set of bench-like hillslopes parallel to the Columbia River, which is about 250 m (820 ft) away.

The trench received approximately 38,000 to 76,000 L/min (10,000 to 20,000 gal/min) of retention basin coolant via a faulty valve until 1963. Other liquid wastes disposed to the trench included coolant water containing debris from fuel element failures, shielding water from the fuel storage basins, and decontamination solution. These liquids contained significant quantities of chemical wastes, including an estimated 300,000 kg of sodium dichromate. An estimated 2,100 Ci of radionuclides was also disposed to the trench, which is the highest curie inventory of all deactivated trenches at the Hanford Site (Dorian and Richards 1978, Carpenter and Coté 1994).

2.4.2 Distribution of Chromium in Groundwater

Chromium is widely distributed in the groundwater in the vicinity of the 116-K-2 Trench, as depicted in Figure 2-12. Monitoring wells are placed more or less along a single line between the trench and the river, so the chromium isopleths represent a general area of contamination. Table 2-5 lists the range and average values of chromium detected in these wells. Other groundwater co-contaminants of note detected in the monitoring wells are carbon-14, strontium-90, tritium, and nitrate (DOE-RL 1994).

Groundwater flows to the northwest, toward the river as depicted by water table contours in Figure 2-12. There are no riverbed substrate sampling data or shallow subsurface shoreline data for chromium. Samples of riverbank seepage revealed chromium concentrations of approximately 65 µg/L (DOE-RL 1992). Chromium was not detected in near-shore river water adjacent to the seepage site.

2.4.3 100-K Area Geology and Stratigraphy

In the 100-K Area, the stratigraphic unit most relevant to interim action design and monitoring is Unit E of the Ringold Formation. Other units relevant to the distribution and movement of

chromium include the Hanford formation, Holocene deposits, and the upper mud unit of the Ringold Formation. Between the 116-K-2 Trench and the Columbia River, geologic data are sparse. Cross sections depicted in Figures 2-13 and 2-14 include wells from the KE Reactor area and 600 Area to aid interpretation. The locations of the cross sections are shown in Figure 2-12.

The Ringold Formation is composed of interbedded fluvial deposits consisting of gravels, sands, silts, and clays. This formation is exposed at the surface along the banks of the Columbia River and up to 360 m (1,200 ft) away from the river, including much of the 100-KR-1 Operable Unit. Although the Ringold Formation is not fully penetrated by wells in the 100-K Area, two adjacent deep wells indicate that the Ringold Formation is about 145 m (480 ft) thick.

Ringold Unit E is characterized by alternating layers of consolidated and unconsolidated coarse sands and gravels. Cementation of the unit is variable, but is considered more tightly cemented in the 100-K Area than elsewhere in the 100 Area. This sand and gravel unit is approximately 30 m (100 ft) thick. The Ringold Unit E overlies the Ringold upper mud unit, a paleosol/ overbank deposit consisting of silts and clays with minor lenses of sands and gravels that is approximately 100 m (360 ft) thick.

The contact between the Ringold Formation and the overlying Hanford formation is unconformable and varies in elevation between well locations. Where the Ringold Formation is not exposed at the surface, it is covered by the Hanford formation and Holocene deposits. These deposits gradually increase in thickness and are up to 40 m (130 ft) thick near the southern boundary of the 100-K Area. Between the trench and the river at well K-20, the overlying Hanford formation is about 9 m (30 ft) thick. To the northeast, at wells K-21, K-22, and K-37, the Hanford formation is absent and Unit E of the Ringold Formation is at or near the ground surface.

In the 100-K Area, the Hanford formation is generally coarser grained than in the other reactor areas. Much of the Hanford formation in the vicinity of the 100-K Area consists of reworked Ringold Formation. The upper 5 m (16 ft) of the Hanford formation can consist of open-framework boulder-cobble gravels. The maximum observed clast size in these gravels is up to 2 m (6 ft). Clasts generally average 0.25 to 0.5 m (0.8 to 1.6 ft) in most of these boulder-rich deposits. Where boulder-rich strata are absent or less abundant (north and east of 100-K), Hanford gravels are dominated by the open-framework pebble to cobble gravels. Holocene deposits in the 100-K Area are limited to river gravels, overbank silty sands, and occasional eolian deposits that create a thin, irregular veneer, generally less than 5 m (16 ft) thick (Lindberg 1993).

2.4.4 100-K Area Hydrogeology

When the 116-K-2 Trench was in operation, the full length was filled to capacity with reactor effluents (Carpenter and Coté 1994). A groundwater mound about 6 m (20 ft) higher than the natural water table was created and caused an increase in the rate of groundwater flow to the river, to perhaps 3 m/day (10 ft/day) (Brown 1963).

Large washouts of reactor coolant and effluents occurred at four distinct areas at the base of the trench. Seepage occurred over large areas and flowed down the hillslope until reaching the river. More than 50 Ci of radionuclides were estimated to be present in the soil column adjacent to the trench (Dorian and Richards 1978). Residual radiological contamination in the vadose zone between the trench and river are indicative of the trench seepage. This suggests a slow rate of infiltration into the Ringold Formation and much more rapid lateral percolation through the relatively permeable, shallow surficial sediments. Therefore, chromium may be distributed at relatively shallow depths in the unconfined aquifer and in less cemented, more permeable portions of the Ringold Unit E, which provide preferential flow paths.

The water table underlying the 116-K-2 Trench is in the Ringold Formation Unit E, approximately 20 m (66 ft) or less below the ground surface. Water levels in the monitoring wells fluctuate in response to river stage changes (see Figure 2-5 and Table 2-6). When the water table rises, residual chromium present in the vadose zone may be introduced to groundwater. Fluctuations in water levels may also affect extraction well pump output and efficiency and will cause the hydraulic radius of influence to vary.

The unconfined aquifer is situated almost entirely in the Ringold Unit E and is approximately 26 m (85 ft) thick. The base of the unconfined aquifer is formed by the Ringold upper mud unit. Near the river, the extent and thickness of the Ringold Unit E is not known, and some of the aquifer may be composed of more permeable Hanford formation or Holocene deposits. Less permeable aquifer materials may release chromium at a slower rate than the more permeable sediments. This may cause a chromium concentration "tailing effect" and should be considered when evaluating interim action effectiveness.

The vertical distribution of chromium in the unconfined aquifer is not known. Collection of samples at varying depths will provide data useful in evaluating effectiveness of the interim action. The vertical gradient of the confined aquifer is upward as demonstrated by the higher water level in well K-32B. This well is consistently 3 m (10 ft) above water levels in wells parallel to the trench that are screened in the uppermost part of the unconfined aquifer. If there is upward leakage to the unconfined aquifer, the presence of chromium in the lower part of the unconfined aquifer is even less likely.

Well performance pumping tests were recently conducted as part of interim action design activities in wells K-18, K-19, K-20, K-21, K-22, and K-37. The estimated geometric mean hydraulic conductivity is 6.1 m/day (20 ft/day) (Edrington 1996). During the limited field investigation, a slug test was performed at well K-37 and a hydraulic conductivity value of 44 m/day (145 ft/day) was estimated (DOE-RL 1994). For comparison, in 1994, slug tests were conducted at six new wells located to the west, in the vicinity of K-East and K-West fuel storage basins. These wells were completed in the upper part of the unconfined aquifer in Ringold Unit E sands and silty sands. Hydraulic conductivity estimates ranged from 1 to 10 m/day (3 to 32 ft/day) (Johnson et al. 1995).

Figure 2-1. Chromium in Groundwater Underlying the 100-H Area.

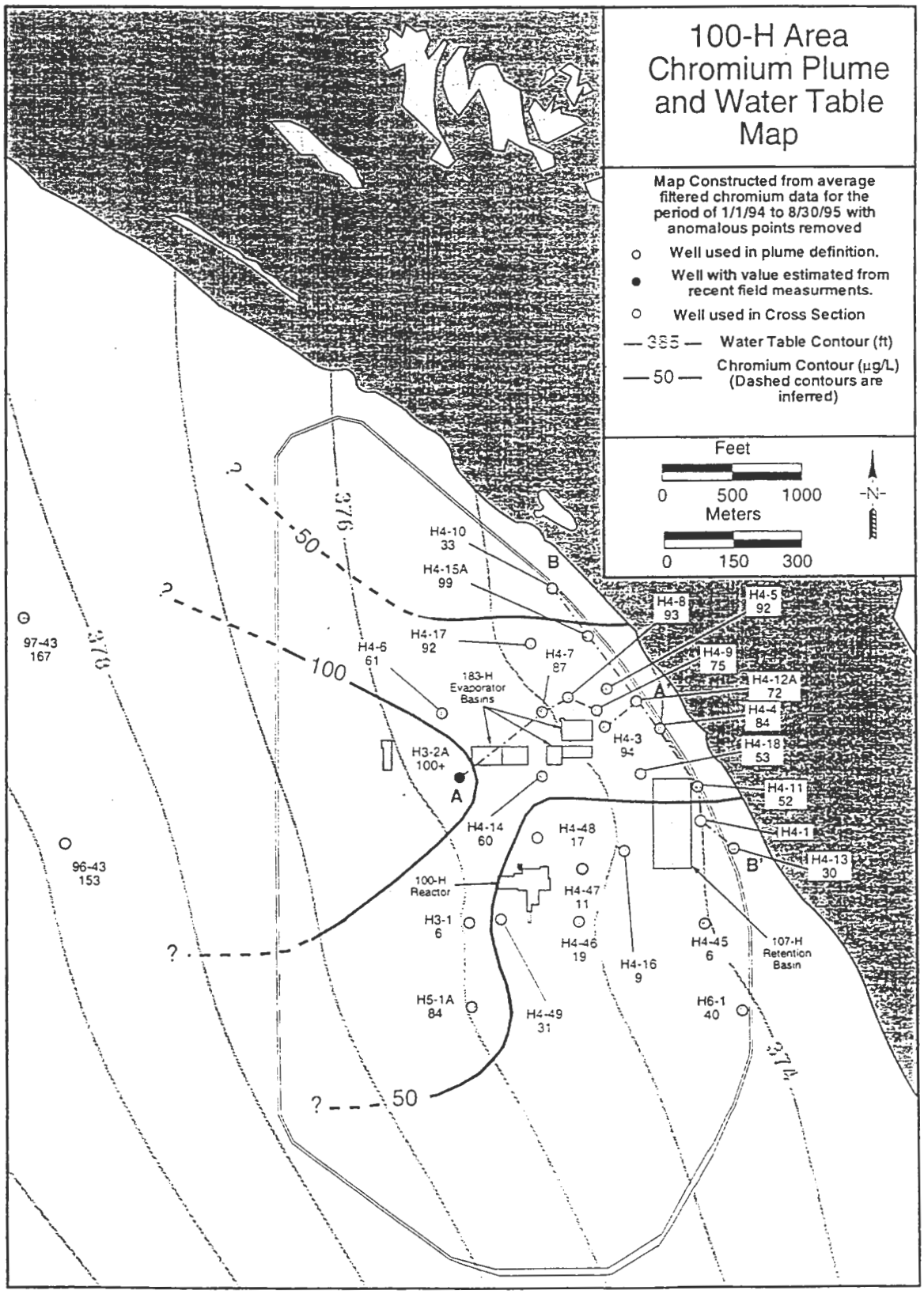
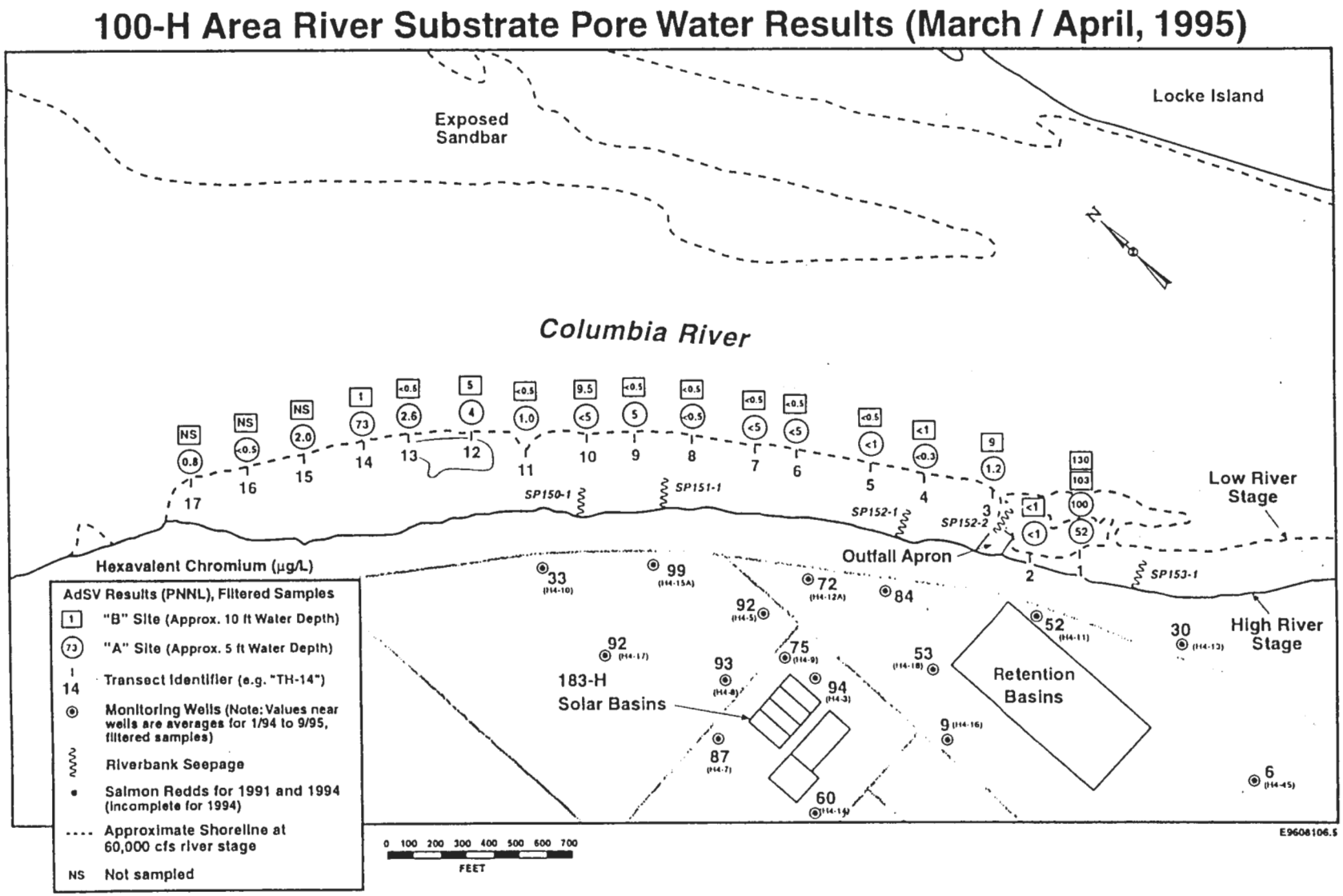


Figure 2-2. Chromium in River Substrate Pore Water Adjacent to the 100-H Area.



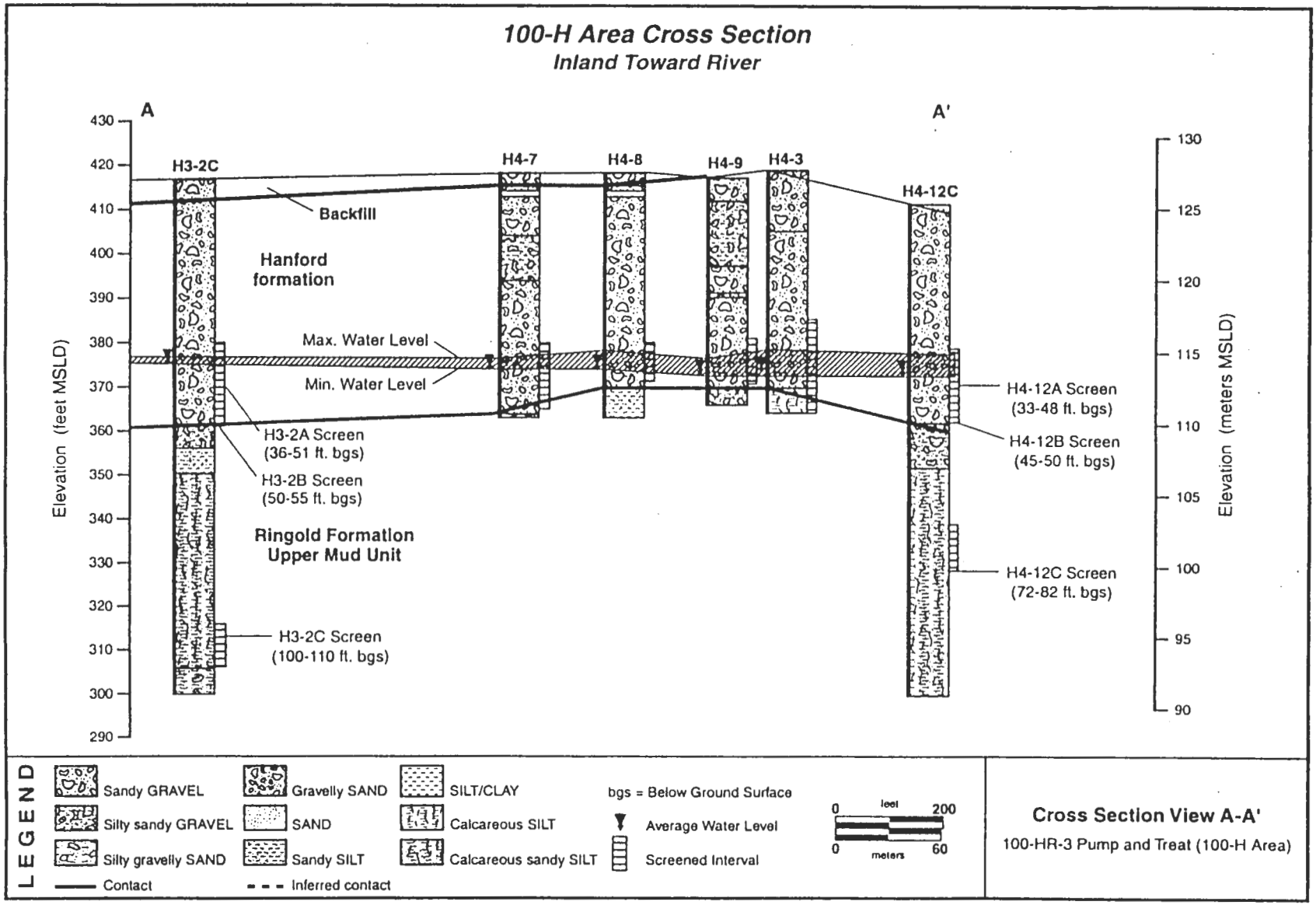


Figure 2-3. Geologic Cross Section Inland Toward the River at the 100-H Area.

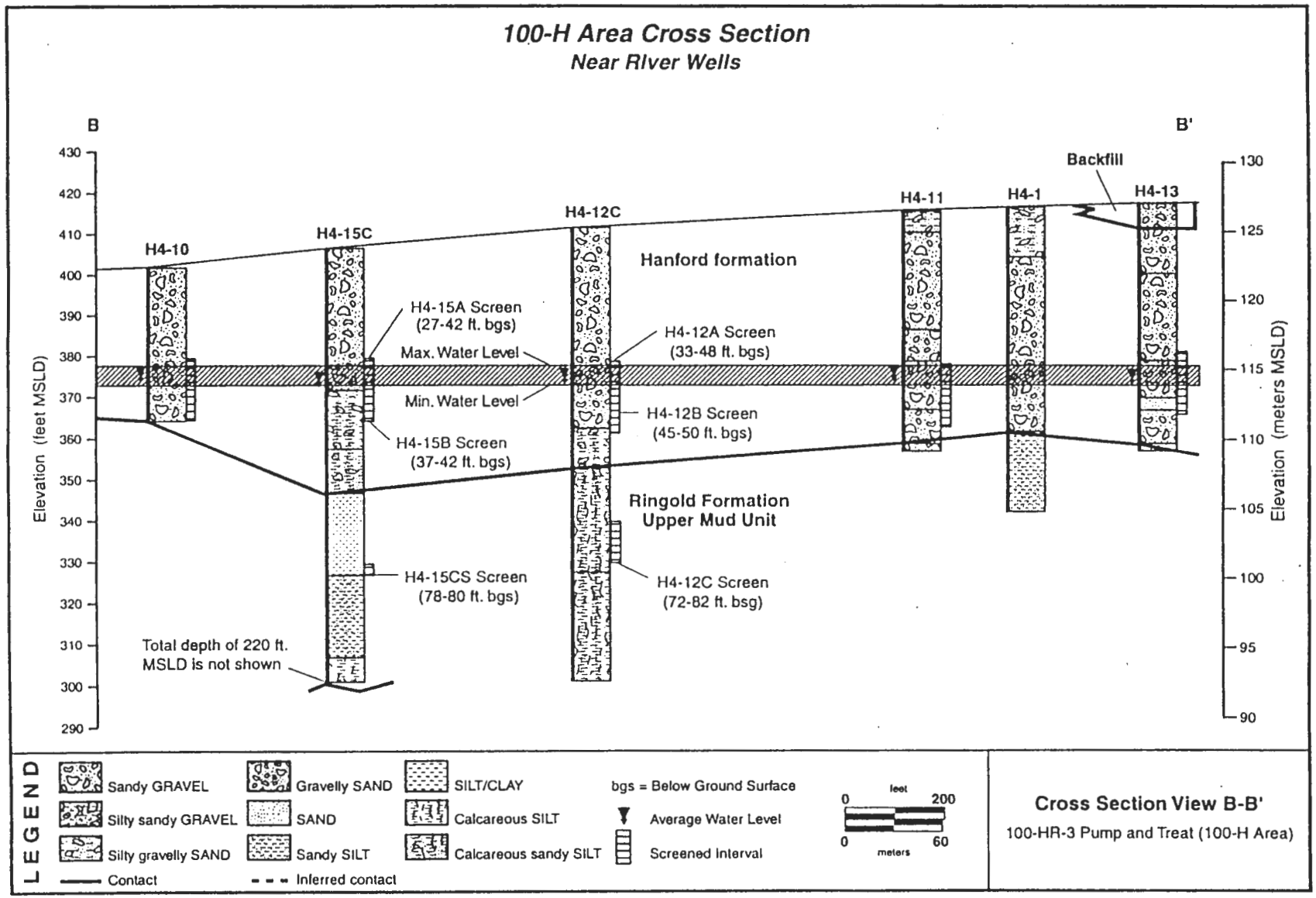


Figure 2-4. Geologic Cross Section Near River Wells at the 100-H Area.

Figure 2-5. Hydrographs for the Columbia River and Selected Wells in the 100-H, 100-D, and 100-K Areas.

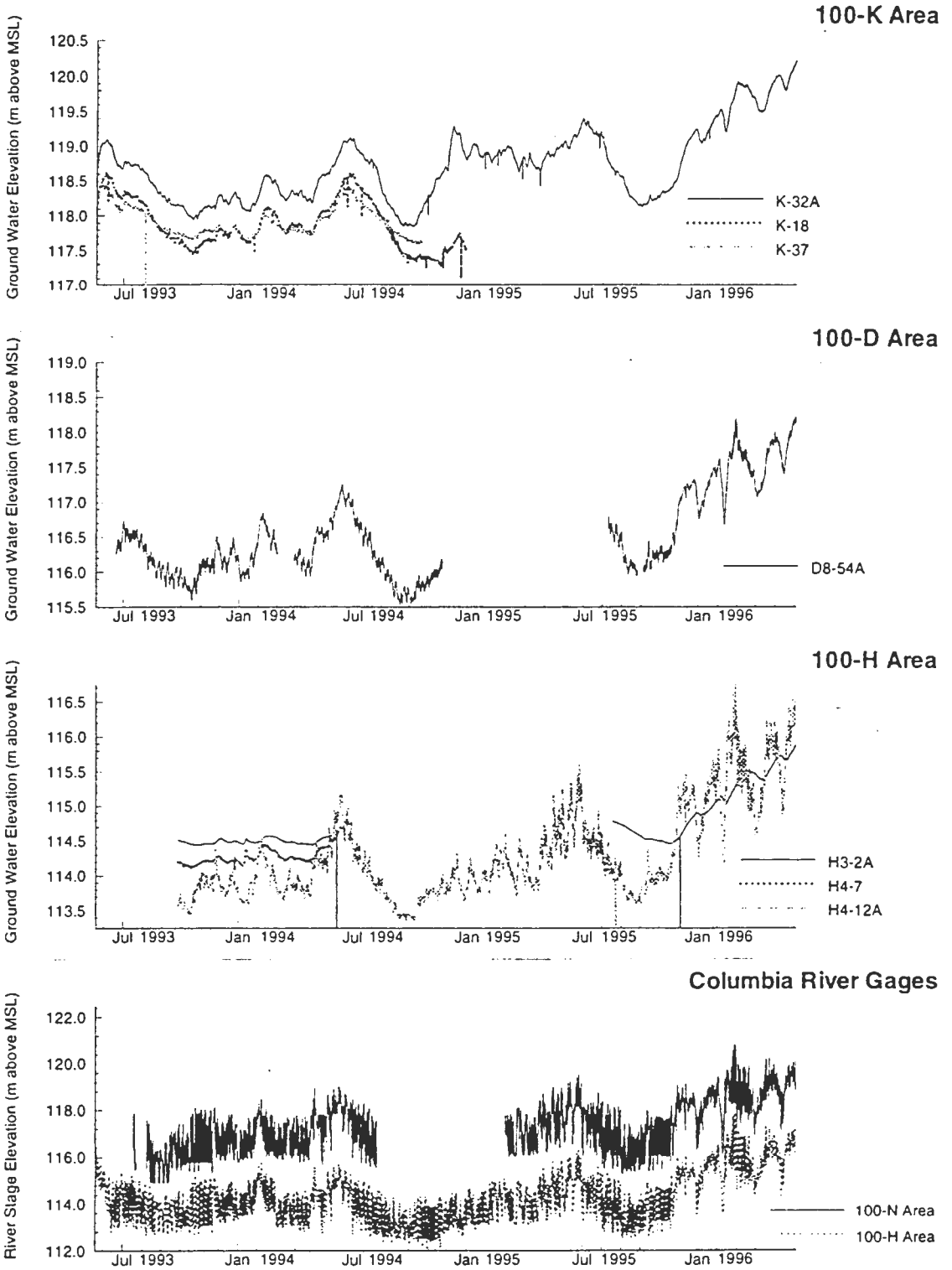


Figure 2-6. Saturated Thickness Map for Uppermost Aquifer Underlying the 100-H Area.

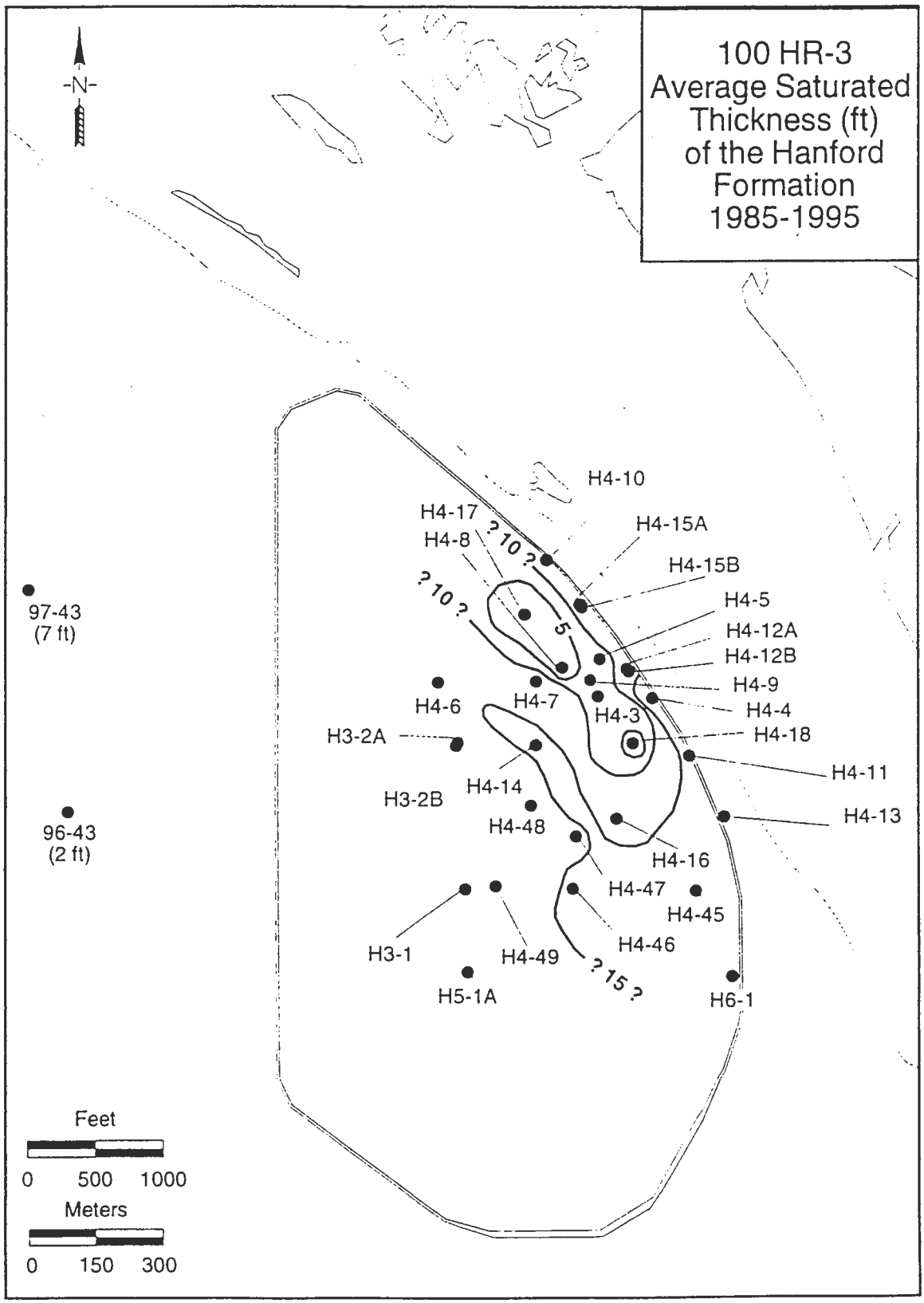
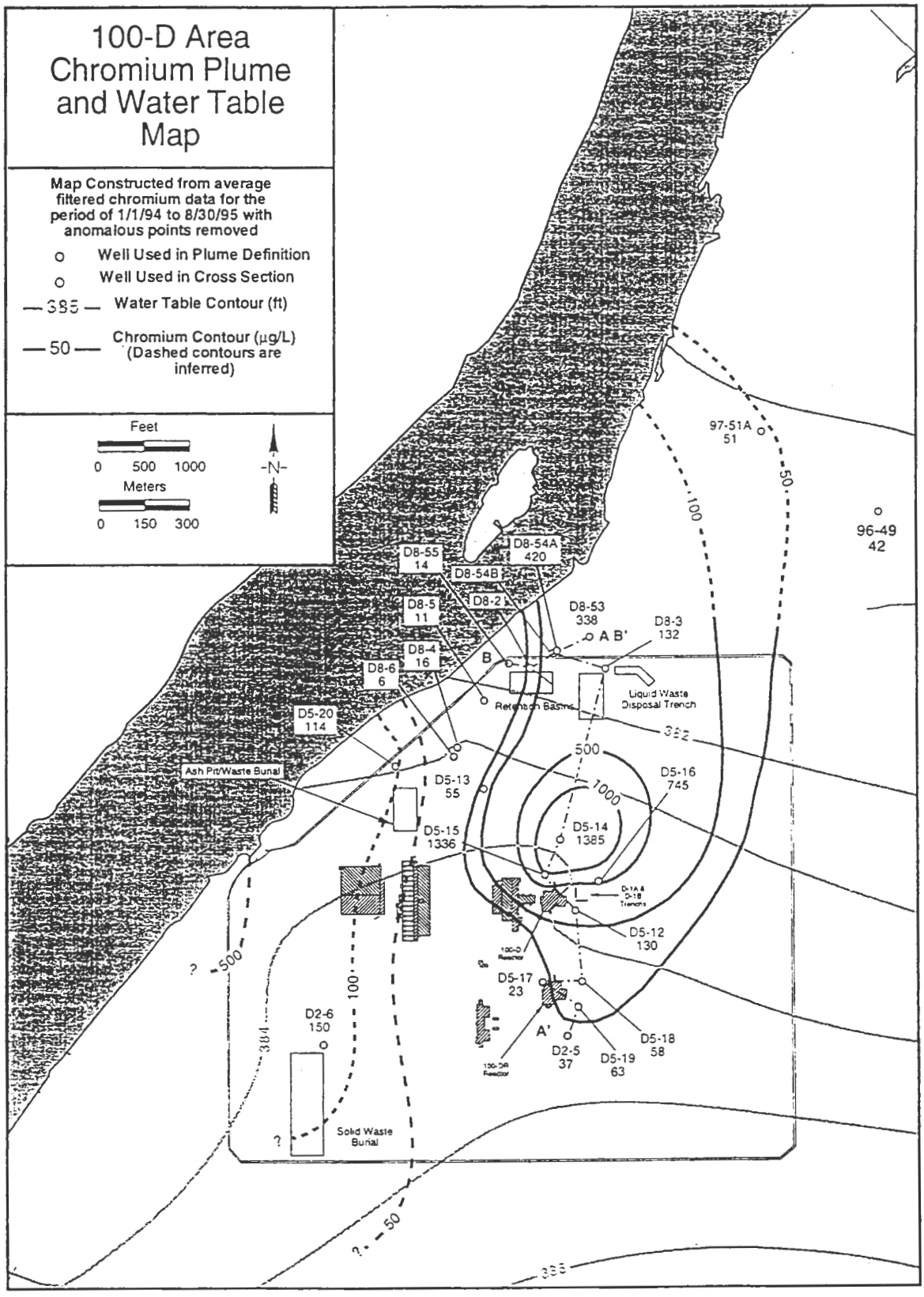


Figure 2-7. Chromium in Groundwater Underlying the 100-D Area.



100-D Area River Substrate Pore Water Results (October / November, 1995)

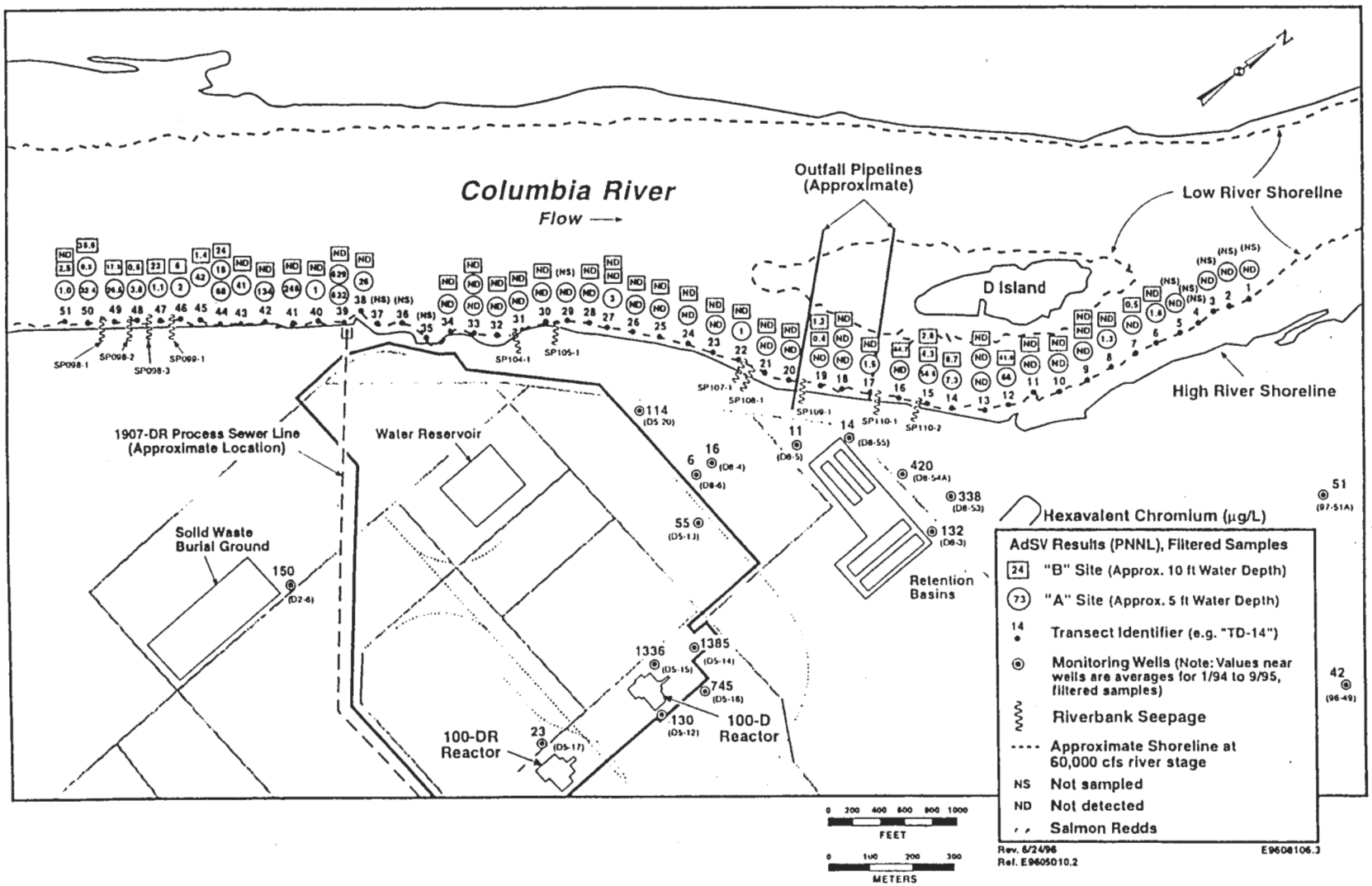
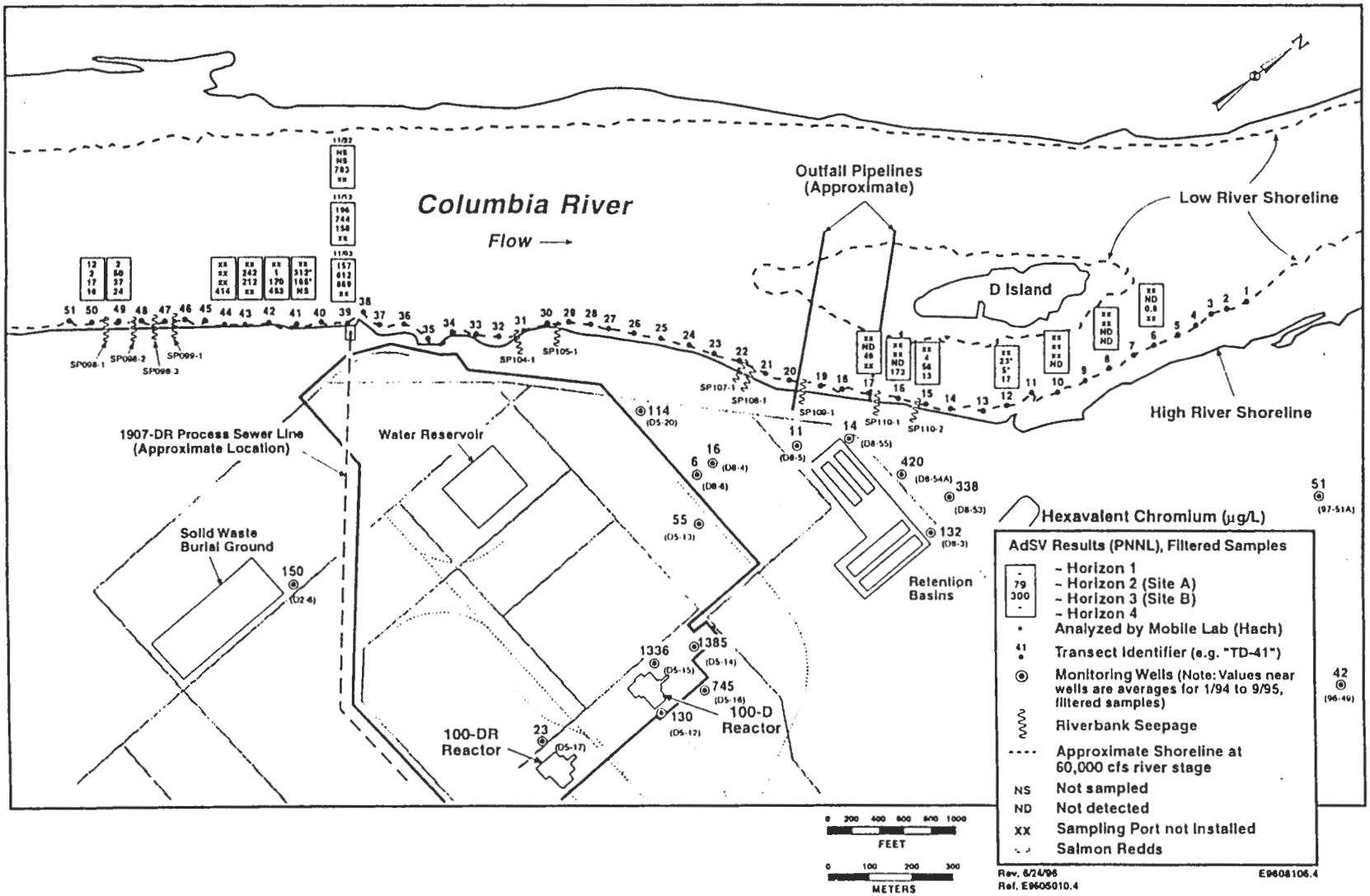


Figure 2-8. Chromium in River Substrate Pore Water Adjacent to the 100-D Area.

Figure 2-9. Chromium at Multiple Depths in Aquifer Along Shoreline at the 100-D Area.



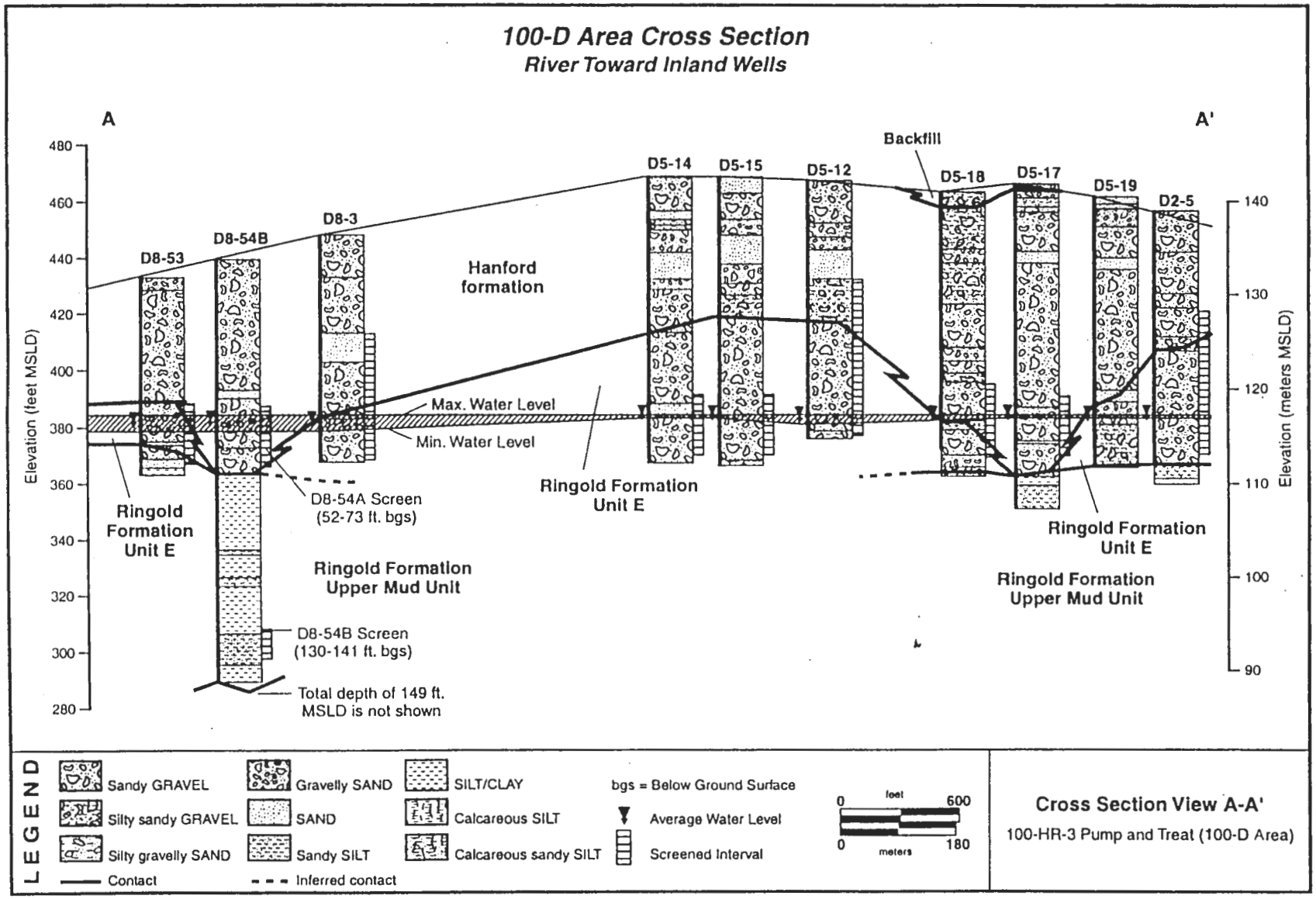


Figure 2-10. Geologic Cross Section River Toward Inland Wells at the 100-D Area.

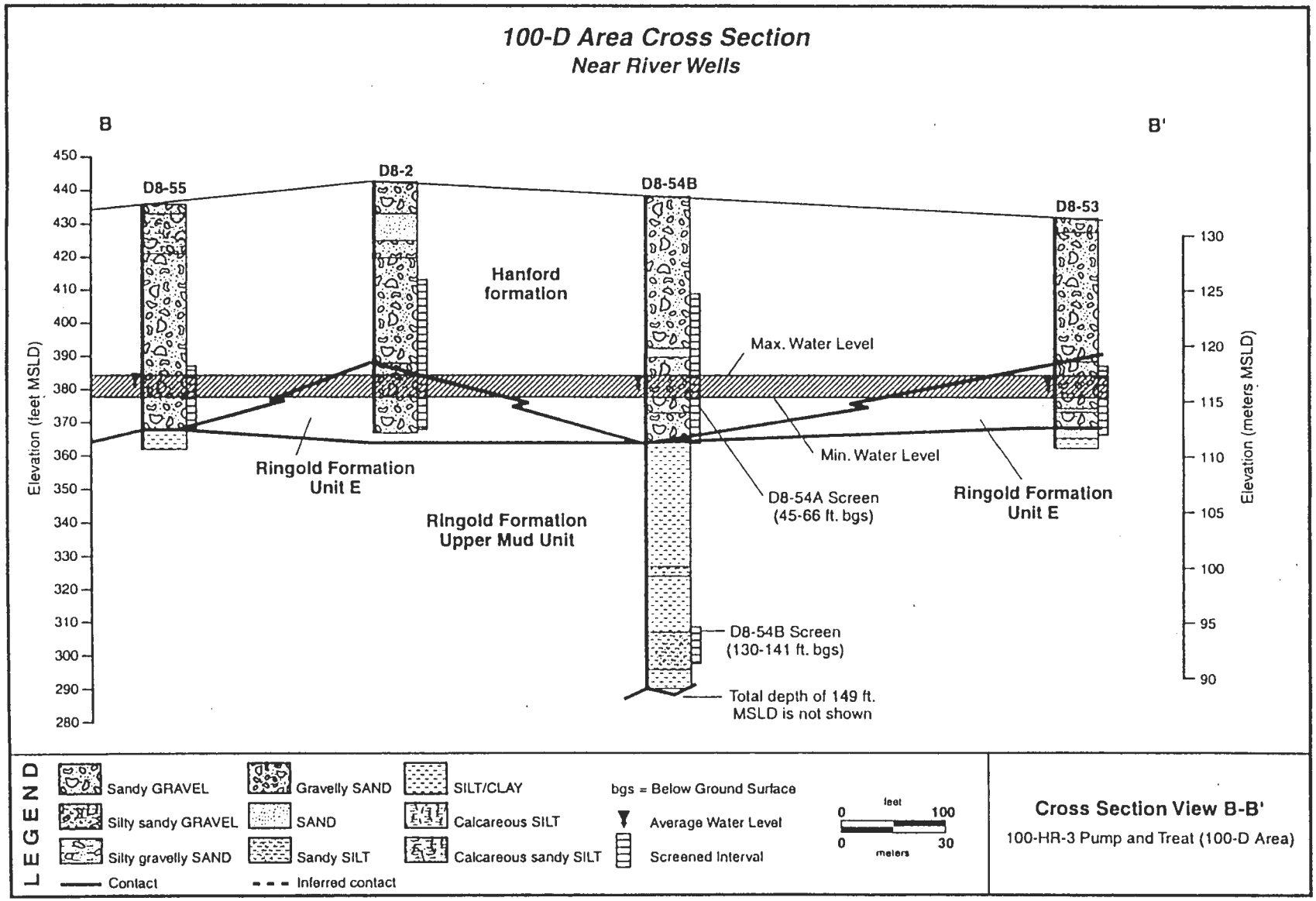
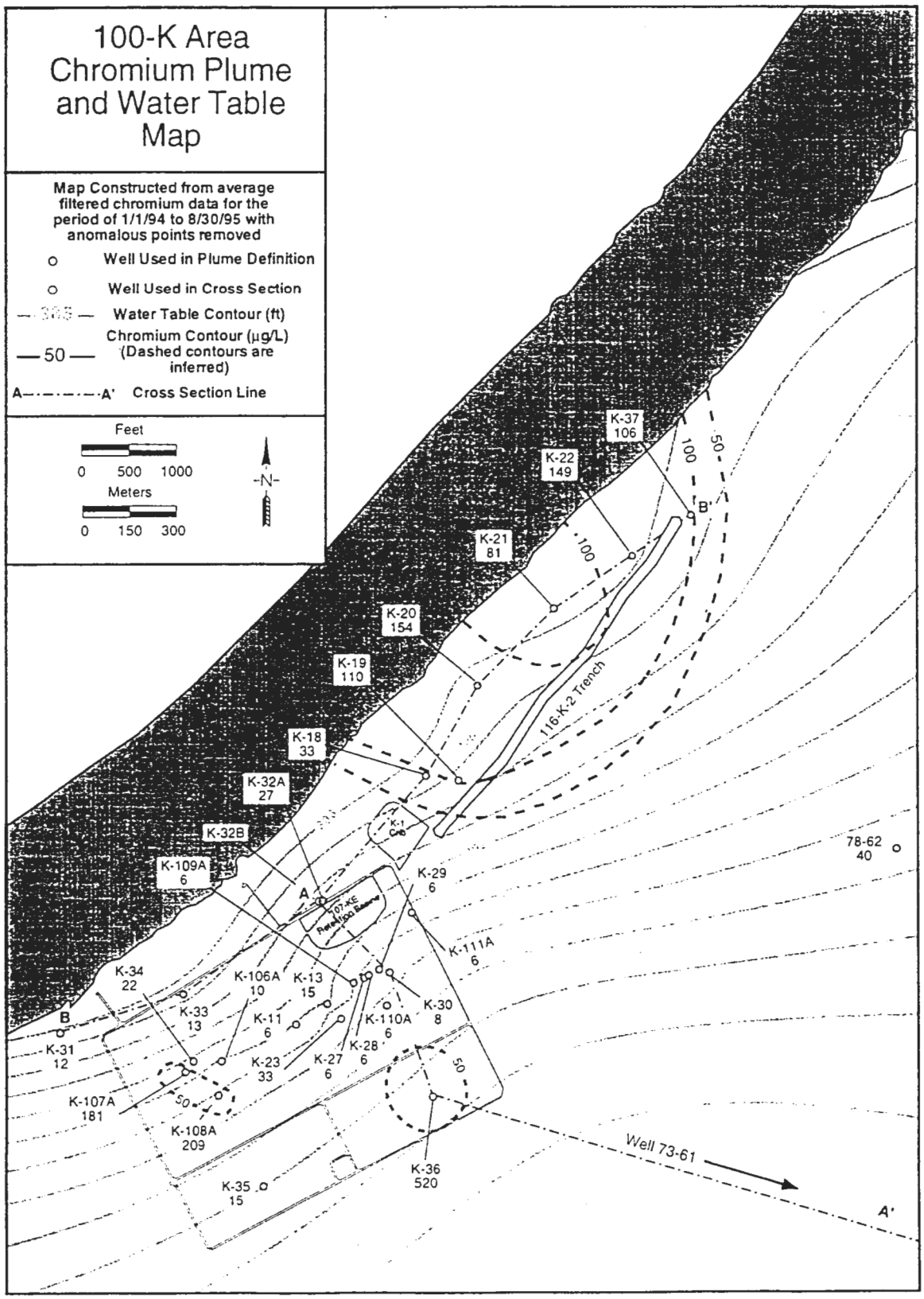


Figure 2-11. Geologic Cross Section Near River Wells at the 100-D Area.

Figure 2-12. Chromium in Groundwater Underlying the 100-K Area.



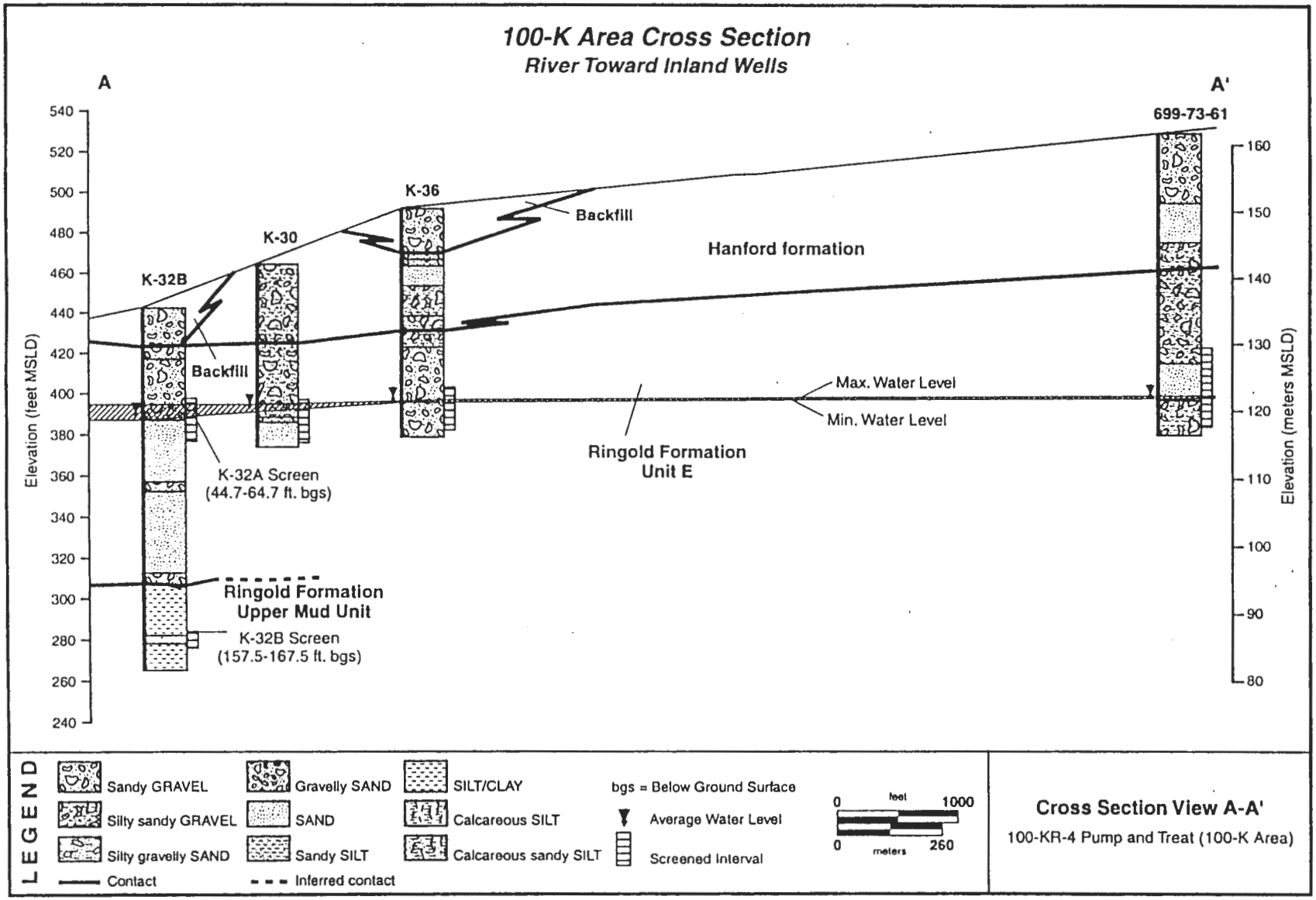


Figure 2-13. Geologic Cross Section River Toward Inland Wells at the 100-K Area.

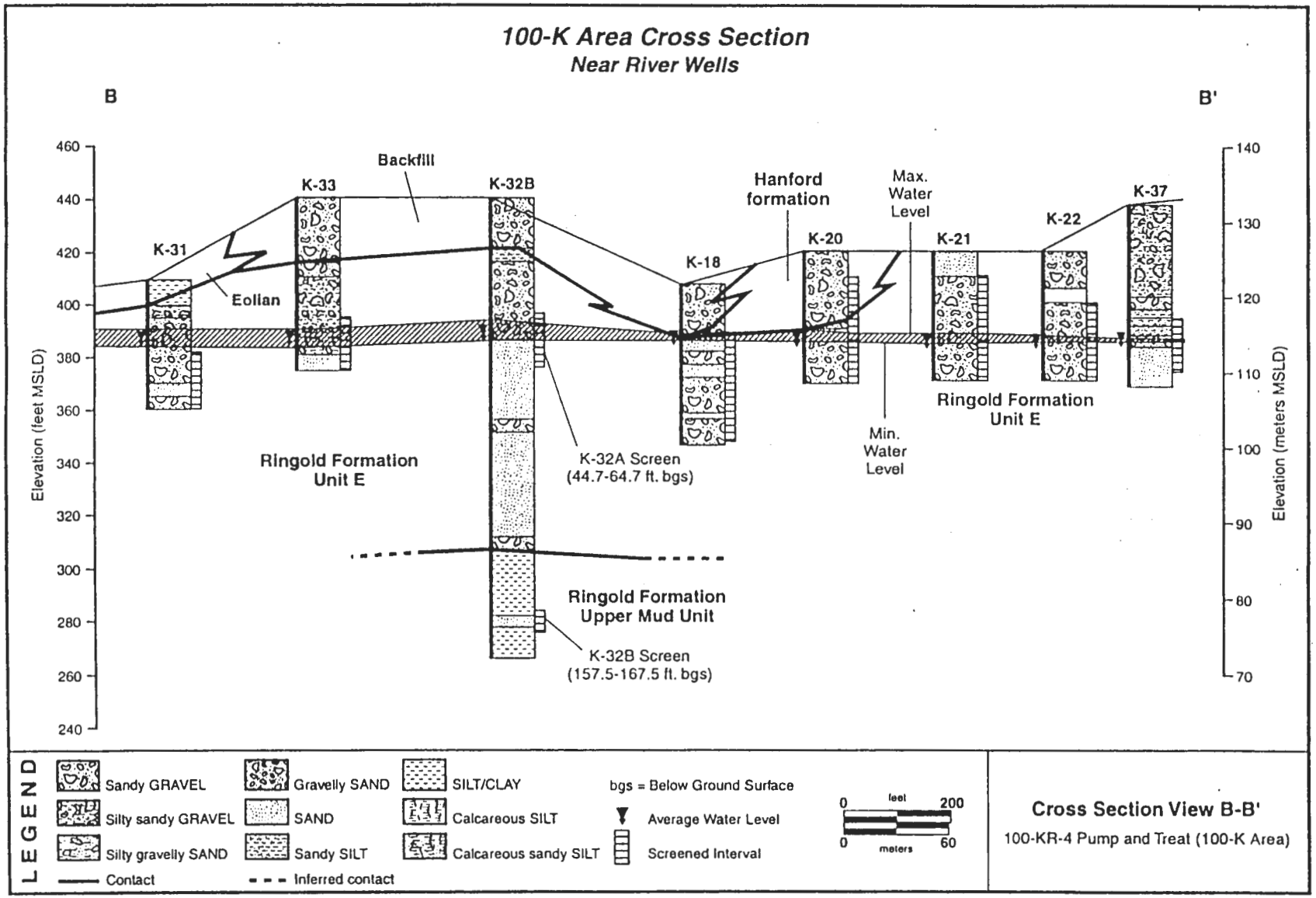


Figure 2-14. Geologic Cross Section Near River Wells at the 100-K Area.

Table 2-1. Chromium Concentrations in 100-H Area Monitoring Wells.

Well Number	Average Chromium Concentration (μg/L), Filtered Samples		
	5/92-10/93 (LFI conditions)	1/94-8/95 (IRM design)	1/95-12/95 (Current conditions)
Wells representative of conditions at or near the water table:			
199-H3-1	NA	7	10
199-H3-2A	63	51	98
199-H3-2B	62	62	78
199-H4-10	50	34	20
199-H4-11	190	52	44
199-H4-12A	50	72	64
199-H4-12B	44	81	73
199-H4-13	53	30	24
199-H4-14	410	60	52
199-H4-15A	106	99	63
199-H4-15B	120	97	97
199-H4-16	32	12	13
199-H4-17	91	92	91
199-H4-18	150	53	55
199-H4-3	44	94	116
199-H4-4	95	84	64
199-H4-45	10	5	7
199-H4-46	43	19	29
199-H4-47	5	11	41
199-H4-48	9	17	43
199-H4-49	23	31	50
199-H4-5	100	92	95
199-H4-6	97	61	60
199-H4-7	100	87	87
199-H4-8	110	93	95
199-H4-9	31	75	66
199-H5-1A	64	84	80
199-H6-1	34	40	33
699-96-43	152	153	141
699-97-43	162	167	156
Wells with open intervals significantly below the water table:			
199-H3-2C	NA	12	7
199-H4-12C	280	281	276
199-H4-15CS	NA	86	86

Current conditions = most recent monitoring data.
IRM design = monitoring data factored into design.
LFI conditions = data collected during limited field investigation.
NA = not available.
Data source: Hanford Environmental Information System, with postprocessing that included removal of nonrepresentative results.

Table 2-2. Water Level Variability in 100-H Area Wells.

Well Number	Distance Inland (ft)	Water Level (ft)		
		Min/max Range	Average Elevation	Average Depth-to-water
Wells representative of conditions at or near the water table:				
199-H4-4	400	6.2	373.98	40.27
199-H4-10	410	4.8	374.62	30.34
199-H4-11	420	5.7	373.95	43.40
199-H4-12A	440	4.9	374.31	39.68
199-H4-12B	440	4.9	374.38	39.64
199-H4-15A	460	4.8	374.48	33.24
199-H4-15B	460	4.7	374.53	32.89
199-H4-13	500	5.9	373.63	45.07
199-H4-5	560	4.2	374.34	42.42
199-H4-18	710	2.8	374.59	47.72
199-H4-9	720	5.3	374.46	44.12
199-H4-3	730	5.5	374.53	46.30
199-H4-17	810	3.1	374.77	45.61
199-H4-8	810	4.6	374.91	44.82
199-H4-45	960	1.9	374.04	42.60
199-H4-7	1,050	2.2	375.02	46.07
199-H6-1	1,100	2.0	374.16	43.94
199-H4-16	1,120	1.7	374.94	49.80
199-H4-14	1,300	1.6	375.48	45.60
199-H4-47	1,430	1.4	375.28	49.63
199-H4-48	1,610	1.5	375.52	44.47
199-H4-6	1,610	2.1	375.60	50.50
199-H4-46	1,710	1.5	375.09	49.10
199-H3-2A	1,780	1.5	375.69	42.62
199-H3-2B	1,780	1.5	375.63	43.28
199-H4-49	2,110	1.1	375.96	48.89
199-H3-1	2,300	1.6	375.91	46.06
199-H5-1A	2,660	1.0	375.95	44.21
699-97-43	2,660	0.5	378.38	43.43
699-96-43	3,990	0.4	378.83	43.01
Wells with open intervals significantly below the water table:				
199-H4-12C	430	5.1	374.13	39.89
199-H4-15CR	460	2.2	374.12	33.25
199-H3-2C	1,780	1.5	375.65	43.08

NOTE: Wells listed in order of increasing distance from the river shoreline at low river stage. Depth-to-water measured from top-of-casing (approximately 2 ft above ground level). Data represent conditions between January 1, 1994 and August 30, 1995. Data source is Hanford Environmental Information System.

Table 2-3. Chromium Concentrations in 100-D Area Monitoring Wells.

Well Number	Average Chromium Concentration (μg/L), Filtered Samples		
	5/92-10/93 (LFI conditions)	1/94-8/95 (IRM design)	1/95-8/95 (Current conditions)
Wells representative of conditions at or near the water table:			
199-D2-5	36	37	33
199-D2-6	179	150	155
199-D5-12	397	130	67
199-D5-13	16	56	105
199-D5-14	678	1,385	1,600
199-D5-15	1,816	1,336	998
199-D5-16	887	745	567
199-D5-17	48	25	13
199-D5-18	70	58	NA
199-D5-19	82	63	NA
199-D5-20	187	114	58
199-D8-3	160	132	147
199-D8-4	NA	16	NA
199-D8-5	18	13	14
199-D8-53	317	338	315
199-D8-54A	390	420	413
199-D8-55	13	15	13
199-D8-6	NA	6	5
699-93-48A	16	15	17
699-96-49	45	42	42
699-97-51A	56	51	47
Wells with open intervals significantly below the water table:			
199-D8-54B	6	7	7

NOTE: Wells listed in order of increasing distance from the river shoreline at low river stage. Depth-to-water measured from top-of-casing (approximately 2 ft above ground level). Data represent conditions between January 1, 1994 and August 30, 1995.
Current conditions = most recent monitoring data.
IRM design = monitoring data factored into design.
LFI conditions = data collected during limited field investigation.
NA = not available.
Data source: Hanford Environmental Information System, with postprocessing that included removal of nonrepresentative results.

Table 2-4. Water Level Variability in 100-D Area Wells.

Well Number	Distance Inland (ft)	Water Level (ft)		
		Min/max Range	Average Elevation	Average Depth-to-water
Wells representative of conditions at or near the water table:				
699-101-48B	320	5.4	379.67	10.43
199-D8-55	390	5.1	381.59	57.76
199-D8-5	500	3.9	382.30	70.19
199-D5-20	600	3.3	382.94	85.16
199-D8-54A	600	5.0	381.58	61.20
199-D8-53	700	5.0	381.55	54.48
199-D8-4	760	3.2	383.07	85.66
199-D8-6	860	3.6	383.02	93.48
199-D8-3	1,090	4.1	381.46	67.50
199-D5-13	1,300	2.0	383.32	88.17
699-97-51A	1,650	2.0	381.09	21.16
199-D2-6	2,100	2.1	384.20	85.08
199-D5-14	2,200	0.7	383.88	87.81
199-D5-15	2,410	0.9	384.17	87.37
199-D5-16	2,790	0.6	383.80	89.09
199-D5-12	2,940	2.8	383.79	85.82
699-96-49	3,080	5.3	381.40	37.80
199-D5-17	3,360	0.9	384.49	85.00
199-D5-18	3,670	0.6	384.32	82.36
199-D5-19	3,800	0.5	384.63	80.17
199-D2-5	3,950	0.8	384.70	75.51
Wells with open intervals significantly below the water table:				
199-D8-54B	600	7.8	382.22	60.29

NOTE: Wells listed in order of increasing distance from the river shoreline at low river stage. Depth-to-water measured from top-of-casing (approximately 2 ft above ground level). Data represent conditions between January 1, 1994 and August 30, 1995. Data source is Hanford Environmental Information System.

Table 2-5. Chromium Concentrations in 100-K Area Monitoring Wells.

Well Number	Average Chromium Concentration (μg/L), Filtered Samples		
	5/92-10/93 (LFI conditions)	1/94-8/95 (IRM design)	1/95-7/95 (Current conditions)
Wells representative of conditions at or near the water table:			
199-K-106A	NA	11	7
199-K-107A	NA	182	228
199-K-108A	NA	209	268
199-K-11	11	6	5
199-K-110A	NA	7	5
199-K-13	46	15	21
199-K-18	25	33	37
199-K-19	114	110	99
199-K-20	159	154	152
199-K-21	77	81	80
199-K-22	169	149	161
199-K-23	75	33	47
199-K-27	6	NA	NA
199-K-28	7	7	NA
199-K-29	7	6	NA
199-K-30	7	8	5
199-K-31	12	13	14
199-K-32A	17	27	30
199-K-33	6	14	9
199-K-34	113	23	19
199-K-35	12	15	14
199-K-36	1,092	520	1,401
199-K-37	116	106	103
699-70-68	NA	6	NA
699-73-61	7	7	8
699-78-62	41	40	39
Wells with open intervals significantly below the water table:			
199-K-32B	5	8	7

NOTE: Wells listed in order of increasing distance from the river shoreline at low river stage. Depth-to-water measured from top-of-casing (approximately 2 ft above ground level). Data represent conditions between January 1, 1994 and August 30, 1995.
Current conditions = most recent monitoring data.
IRM design = monitoring data factored into design.
LFI conditions = data collected during limited field investigation.
NA = not available.
Data source: Hanford Environmental Information System, with postprocessing that included removal of nonrepresentative results.

Table 2-6. Water Level Variability in 100-K Area Wells.

Well Number	Distance Inland (ft)	Water Level (ft)		
		Min/max Range	Average Elevation	Average Depth-to-water
Wells representative of conditions at or near the water table:				
199-K-31	350	6.7	386.25	26.15
199-K-20	560	4.3	386.35	35.59
199-K-21	700	3.7	385.57	36.12
199-K-33	800	5.9	386.66	56.98
199-K-18	840	3.7	386.54	23.41
199-K-32A	900	7.3	388.55	55.47
199-K-22	1,060	3.1	385.82	38.65
199-K-19	1,100	3.5	387.30	34.80
199-K-37	1,150	2.4	386.68	55.12
199-K-107A	1,350	3.4	390.52	77.11
199-K-34	1,390	3.5	390.25	77.84
199-K-106A	1,580	7.0	391.11	76.18
199-K-110A	1,660	2.3	393.29	74.68
199-K-13	1,680	2.3	391.11	74.50
199-K-109A	1,770	2.1	391.92	76.28
199-K-11	1,780	2.4	390.95	75.55
199-K-27	1,800	3.1	392.34	74.34
199-K-28	1,810	4.4	391.96	74.01
199-K-108A	1,820	4.6	392.10	76.13
199-K-29	1,850	4.1	392.46	74.93
199-K-23	1,890	1.9	392.68	75.50
199-K-30	1,910	2.6	392.67	73.54
199-K-111A	2,160	4.9	391.40	70.64
699-72-73	2,343	1.4	395.70	86.89
199-K-35	2,820	1.1	394.99	99.56
199-K-36	3,100	1.3	395.51	98.56
699-78-62	5,220	0.8	393.57	76.12
699-70-68	6,660	0.7	397.67	128.40
699-73-61	9,310	0.6	397.57	133.87
Wells with open intervals significantly below the water table:				
199-K-32B	900	2.2	396.77	48.50

NOTE: Wells listed in order of increasing distance from the river shoreline at low river stage. Depth-to-water measured from top-of-casing (approximately 2 ft above ground level). Data represent conditions between January 1, 1994 and August 30, 1995. Data source is Hanford Environmental Information System.

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3.0 REMEDIAL DESIGN

This chapter describes the engineering, hydrogeologic, and regulatory design basis for the 100-HR-3 and 100-KR-4 pump-and-treat systems, and provides a general description of the system's components and their function. More detailed information on the remedial design can be found in supporting documentation described in Section 3.1.

3.1 SUPPORTING DOCUMENTATION

The 100-HR-3 and 100-KR-4 design efforts have produced other documents intended to communicate information between the design team, review staff, and the contractor(s) who will build the system. These documents contain cost and technical information used to support project decision making. The following subsections summarize the purpose and content of several key documents that are available through ERC's Document Information Services.

3.1.1 Conceptual Design Documents

Significant documents produced during the conceptual design phase include the following:

- *Design Criteria and Design Basis for the 100-HR-3 and 100-KR-4 Pump-and-Treat Projects* (BHI 1996c). This document identifies relevant criteria applicable to the pump-and-treat design and describes the design basis. The document served as a project work plan for the ERC design team.

- Revision A drawings and specifications and a system design description. These documents show the general layout of the pump-and-treat system and configuration of the system's controls and interfaces. These documents were used to communicate information to the ERC review team before completion of the final drawings and specifications.

- *100-HR-3 and 100-KR-4 Interim Remedial Measures Pump-and-Treat Acquisition and Design Strategy Plan* (BHI 1996a). This document provides general information on the scope, schedule, and value of subcontracts proposed for award during the interim action construction phase. This document is used internally by project management for subcontract award planning and to identify key milestone dates.

3.1.2 Final Design Documents

The principal documents produced during final design include final design drawings, specifications, and other related information for bidding on and construction of the pump-and-treat systems. The final design drawings and specifications were incorporated into the following procurement packages:

- *100-HR-3 and 100-KR-4 Pump-and-Treat Drilling Description of Work* (BHI 1996b). This document was used to obtain DOE and regulatory agency concurrence on the following: (1) location and construction of new extraction, injection, and monitoring wells; (2) rehabilitation of existing wells; and (3) management of drilling and development wastes generated during well construction.

- Balance-of-Plant Procurement Package. This package contains the final drawings and specifications necessary for construction of the pump-and-treat system, exclusive of the wells. Detailed information on site grading, piping layout, well controls, tank locations, the groundwater treatment system (GTS), and electrical mechanical connections are included.

3.1.3 Implementation Documents

Implementation documents, to be prepared before or during interim action construction, will address activities necessary to support construction, startup, and operation of the pump-and-treat system. Several key documents planned at this time include the following:

- Construction Quality Assurance Plan. This plan will be a compilation of DOE and ERC field inspection and quality assurance protocols for use during construction and functional testing of the balance of plant and GTS skid.

- Construction Health and Safety Plan. This plan will provide information on field oversight health and safety protocols used during construction.

- Operations and Maintenance Plan. This plan, to be prepared during the construction phase, will be a compilation of as-built drawings, equipment specifications, owner manuals, training requirements, and DOE/ERC procedures for performance of specific activities related to operation and maintenance of the pump-and-treat system.

- Treatment Plan for Protection of Cultural Resources for the 100-KR-4 Pump-and-Treat Project. This document will describe the approach and methods to be used for protecting cultural resources in the 100-K Area.

- Mitigation Action Plan. This document will provide mitigation strategies to be used to prevent or reduce impacts to cultural ecological resources present at the 100-HR-3 and 100-KR-4 pump-and-treat sites and provide guidance on revegetation after the projects are completed.

- Waste Management Plan. This plan will describe waste management requirements for system operations.

- Performance Monitoring Plan. This plan will integrate monitoring activities designed to meet the interim action ROD requirements with those necessary to safely operate the pump-and-treat system and ensure optimum operation. The performance monitoring plan will provide a detailed description and schedule of monitoring activities including data management and evaluation methods. This document will serve as a work plan for project management staff and as a sampling and analysis plan for field support staff. The plan will address the following monitoring programs:

  1. Compliance Monitoring Program. This program describes the location, methods, and frequency of monitoring required to meet the objectives described in the interim action ROD and to demonstrate successful completion of the interim action or conditions warranting its termination. The compliance monitoring program approach is described in Chapter 5.0 of this document.

  2. Performance Monitoring Program. This program describes the locations, methods, and frequency of monitoring conducted to (1) determine the effects of the interim action on groundwater flow and plume distribution, (2) support remedial investigation/feasibility study data needs for selection of the final remedy, (3) optimize system performance, and (4) support or describe data sharing with other regulatory programs.

  3. Operational Monitoring Program. This program will describe monitoring necessary to support (1) documentation of safe operation and system function, (2) maintenance schedules, and (3) project cost controls.

3.2 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The remedial actions described in this document are required to comply with the applicable or relevant and appropriate requirements (ARAR) established in the interim action ROD and in accordance with the *National Oil and Hazardous Substances Pollution Contingency Plan* (NCP).

All remedial design and remedial action activities associated with the 100-HR-3 and 100-KR-4 interim action will occur "on site," as that term is defined in the NCP. As such, remedial actions planned for these operable units need only meet the substantive requirements of the ARARs established in the interim action ROD.

Fifteen different chemical-specific, action-specific, and location-specific ARARs were identified during preparation of the focused feasibility study and the interim action ROD. The approach for meeting each of the ARARs is discussed in detail in Appendix A.

3.3 ENGINEERING AND HYDROGEOLOGIC DESIGN BASIS

The primary remedial action objective for the 100-HR-3 and 100-KR-4 interim action is to prevent the discharge of hexavalent chromium to the Columbia River substrate at concentrations exceeding those that are considered protective of aquatic life in the river and riverbed sediments. This objective will be achieved by pumping groundwater from extraction wells located along and inland from the river shoreline, treating the groundwater to remove hexavalent chromium using an ion-exchange treatment method, and returning the treated groundwater to the aquifer with injection wells. This section describes the general approach used to select extraction and injection well locations, criteria for piping and flow control and monitoring equipment (balance of plant), and the rationale for selecting resin(s) to be used in the ion-exchange treatment system.

The general approach used for developing the system design included the following activities:

- Preparation of an updated conceptual model of groundwater flow and chromium distribution in each of the three areas using water quality and elevation data obtained between January 1994 and August 1995 (see Figures 2-1, 2-7, and 2-12). This period was selected as the design baseline because it represented the timeframe for which the most recent data were available, and enabled the effect of temporal fluctuations to be "smoothed" by averaging individual data results over a range of conditions likely to occur. This information was then integrated with the results of river substrate sampling, where available, to define the geographic area to be addressed by the interim action.

- Completion of well performance tests to assess the utility of using existing monitoring wells for groundwater extraction by evaluating well construction details and potential yields.

- Development of a numerical model for simulating groundwater flow and optimizing the location and pumping rates of extraction and injection well locations with respect to chromium distribution maps (Appendix B).

- Use of input from the numerical modeling and well performance tests to size the various balance-of-plant components including pipe diameters and lengths, flow monitoring and control devices, pumps, tank storage, and system electrical/mechanical requirements.

- Testing of various ion-exchange resins to evaluate chromium removal efficiencies for conditions anticipated at the time of extraction and treatment system startup.

The information generated from the above activities was integrated with standardized design details and experience gained from the N-Springs pump-and-treat project to produce a cost-effective design package.

The following subsections contain a summary of regulatory and technical information used to develop the design basis for the groundwater extraction and injection systems and the GTS.

3.3.1 100-HR-3 Design Basis

The 100-HR-3 Operable Unit includes groundwater under the 100-H and 100-D Reactor areas. The two sites are located within the same operable unit boundary, but are approximately 4 km (2.5 mi) apart. Because of their geographic separation and subsurface hydrogeologic differences, the groundwater extraction system design for each area was developed independently. However, to reduce overall project costs and facilitate operation and maintenance requirements, the two areas will share a common treatment system and injection area located in the 100-H Area.

3.3.1.1 100-HR-3 Interim Action Target Area. In the 100-H Area, the target area includes a group of near-river wells and nearby inland wells situated at the leading edge of the chromium plume. By proximity to the river, these wells are situated in a portion of the plume considered to pose the greatest threat to the ecological receptor in the river (Figure 3-1). In the first survey of chromium in the river substrate, there were few detections along the 100-H Area shoreline. The correlation of these substrate samples to the present distribution of the chromium plume is not yet clearly established. Therefore, where chromium was detected in the substrate, existing near-river wells located immediately upgradient were included in the interim action target area.

The initial plume target area was approximated by the area within the 50-µg/L chromium concentration contour. This contour interval encompasses a substantial portion of the near-river chromium plume, including those shoreline locations where the potential for river substrate concentrations of chromium exceeding 11 µg/L is considered greatest. By targeting the near-river portion of the plume that exceeds the 50-µg/L chromium concentration, the interim action also addresses a secondary remedial action objective, which is to reduce human health-related exposure risks. Based on the response of the aquifer to pump and treat and the measured effectiveness of the interim action on chromium in near-river onshore locations, the initial target area will be revised accordingly.

In the 100-D Area, wells D8-53 and D8-54A, located approximately 100 to 175 m (330 to 580 ft) from the river, have chromium concentrations of 338 and 420 µg/L, respectively (Table 2-3). There are also preliminary river substrate sampling data downgradient from these two wells that indicate chromium is present in the riverbed at concentrations that exceed the 11-µg/L Ambient Water Quality Criteria (Figure 3-2). Because the concentration of chromium in wells D8-55, D8-5, and D8-4, which are located south (upstream) of D8-54A, has been less than 22 µg/L and no water quality data exist for the area north (downstream) of well D8-53, the initial target area for the 100-D Area was defined as the immediate area encompassing wells D8-53 and D8-54A extending downstream to the river (Figure 3-3).

3.3.1.2 Groundwater Extraction System. Installation of new wells generally represents the largest cost and schedule expenditure for groundwater remediation projects. The use of existing wells wherever practicable represents an effective approach to provide significant cost savings. After identifying the target area for each interim action, the following were considered for each area:

- Are existing wells available? If so, is their location adequate to meet the remedial action objective(s)?
- Are the existing wells adequately designed and constructed for use as an extraction well?
- Is the existing well being used for any other purpose that would preclude its use for the interim action?

In developing the 100-HR-3 extraction well network design, an extensive array of existing wells in the 100-H Area and, to a lesser extent, in the 100-D Area provided an excellent opportunity to reduce interim action costs.

3.3.1.2.1 100-H Area. Before extraction well locations were selected, performance tests were conducted on nine monitoring wells in the 100-H Area to evaluate their potential as extraction wells. The criteria used to select the wells were accessibility, construction, thickness of saturated interval, and chromium concentration.

The test results (Table 3-1) indicated that each candidate well, except for well H4-4, was adequate for groundwater extraction. Well H4-4 was in good condition, but produced only 38 L/min (10 gal/min). Although this yield is adequate for monitoring, it provides limited flexibility to be an effective extraction well. Extraction rates measured in the remaining wells ranged from 114 L/min (30 gal/min) (well H4-12A) to more than 1,136 L/min (300 gal/min) (well H3-2A).

Numerical modeling simulations were run to evaluate various well locations and pumping rates. The rationale and results for each scenario are presented in Appendix B. The recommended scenario (Figure 3-4) uses five extraction wells. Wells H4-12A, H4-15A, and H4-11 are located adjacent to the river and will provide rapid hydraulic gradient control and chromium removal from the area in closest proximity to known aquatic habitat. Wells H4-7 and H3-2A are located within the core region of the plume and are favorably positioned to intercept the chromium plume migrating from the 100-D Area. Pumping from these wells will result in rapid mass removal and will decrease the flux of chromium migrating toward the river.

To minimize the potential influx of river water, wells H4-12A, H4-15A, and H4-11 will initially be pumped at a conservative rate of 38 L/min (10 gal/min). Water level and river stage data collected during startup will be used to determine if pumping rates should be adjusted to achieve the desired hydraulic gradient control. Existing wells H4-4 and H4-5 and new wells H4-63 and

H4-64, which initially will be used for compliance monitoring, have been designed for potential use as extraction wells in the event that additional pumping along the shoreline is necessary. Extraction wells H3-2A and H4-7 will be pumped initially at rates of 151 L/min (40 gal/min) and 76 L/min (20 gal/min), respectively. These rates may be adjusted during startup to increase the rate of mass removal or expand the area of hydraulic gradient control.

3.3.1.2.2 100-D Area. Groundwater extraction from the 100-D Area is designed to reduce the flux of chromium migrating toward the river and to intercept chromium detected at transects 12 and 15 in the Columbia River substrate. Existing wells D8-53 and D8-54A are best positioned to achieve these objectives. Well performance tests conducted at these two locations (Table 3-1) confirmed the adequacy of the wells for groundwater extraction use.

A series of numerical modeling simulations (Appendix B) were run using various extraction well pumping rates. The simulations indicate that pumping 151 L/min (40 gal/min) at each well creates a hydraulic capture zone encompassing most of the chromium plume (Figure 3-5). After 2 years of pumping, up to one-third of the flow entering the extraction well may originate from the river.

Water level data collected during interim action implementation will be used to determine if pumping rates should be adjusted to achieve the desired hydraulic gradient control. If additional pumping beyond the capacity of wells D8-53 and D8-54A is required, compliance wells D8-68, D8-69, and D8-70 can be connected to the pump-and-treat system.

The existing 100-HR-3 wells to be used for groundwater extraction are 150 mm (6 in.) in diameter with fully penetrating 0.02-in. slot size well screens. These wells, originally designed for monitoring purposes, possess ample hydraulic capacity for efficient entry of water into the well, while providing flexibility to accommodate alternate pumping rates without well screen or riser casing modifications.

Well H4-12C, where chromium concentrations ranging from 270 to 290 µg/L have been detected, will not initially be connected to the groundwater extraction network. This well is screened at a depth of 22 to 25 m (72 to 82 ft) in the Ringold upper mud unit, and the presence of chromium at this depth, in conjunction with the absence of co-contaminants, cannot be accounted for based on the current conceptual model. This well will be regularly monitored during the interim action to obtain additional information for determining whether its inclusion in the extraction network is warranted.

3.3.1.3 Groundwater Injection System. The selection of a suitable injection area was based on criteria specified in the interim action ROD and technical considerations developed during the hydrogeologic design effort. Hydrogeologic injection criteria contained in the interim action ROD include the following: (1) treated water will be injected into the upper aquifer and (2) injection wells will be located upgradient of the existing chromium plume.

Technical considerations identified during the hydrogeologic design included the following.

- The injection area should be placed in an area where chromium and co-contaminants are expected to occur or potentially be present at low concentrations in vadose zone soil and groundwater.

- The injection area should be placed in an area where mounding of the water table will not adversely impact the distribution or movement of known chromium occurrences.

- The injection area should be of sufficient distance from the extraction wells such that closed cell circulation will not occur until an effective, optimal capture zone in the aquifer is established.

- The number (and cost) of new injection wells could be minimized by allowing the water table to mound into the overlying vadose zone and injecting treated 100-D Area groundwater in the 100-H Area.

The chromium plume approaching from the 100-D Area limited the choice of injection sites to a small area at the southwest corner of the 100-H Area. In addition to meeting the criteria described above, this site is in close proximity to the treatment area.

Based on the numerical modeling results, the injection system will require three wells. The number of wells in full-time operation will depend on GTS throughput and aquifer response to injection. Initially, two wells will be used while the third will serve as a backup and for monitoring purposes.

3.3.1.4 100-HR-3 Balance of Plant. The primary considerations for balance-of-plant design included the following.

- The pump-and-treat system shall have a design life of 10 years under normal operation and maintenance conditions. However, the actual operating lifetime is expected to be significantly less.

- Nominal extraction well flow rates from the 100-HR-3 wells will vary from 38 to 151 L/min (10 to 40 gal/min), with an initial combined flow rate of 341 L/min (90 gal/min) from the 100-H Area wells and 303 L/min (80 gal/min) from the 100-D Area wells. The extraction system shall be flexible to enable additional wells to be connected to the system if necessary. Automatic features will be provided to shut down portions of the system to prevent tank and injection well overflow or if a pipe leak occurs.

- Because of the remote site locations, each system shall require minimal operator attention and allow for remote monitoring.

- Double containment will not be required for piping and tanks because extracted groundwater is not a dangerous waste by *Washington Administrative Code* (WAC) Chapter 173-303-070.

- Operating parameters and control set points will be established and verified during plant startup. Once the system becomes operational, set points will be changed to optimize operation.

Much of the balance-of-plant equipment design originated from N-Springs and experience gained from operation of that system. Wherever practicable, similar equipment has been used to minimize operator training, reduce costs and downtime associated with replacement parts inventory, and facilitate troubleshooting and repair. The use of a standardized design should also simplify procurement and construction.

3.3.1.5 100-HR-3 Groundwater Treatment System. The interim action ROD does not establish a fixed treatment level for chromium. It does, however, state that chromium shall be treated to the maximum extent practicable, and treated water containing chromium exceeding 50 µg/L will not be injected. No treatment requirements for co-contaminants are prescribed.

Ion exchange using a strong base resin is the treatment technology described in the interim action ROD for removing chromium from groundwater. Bench-scale testing and experience gained from operation of the 100-HR-3 pilot-scale treatability system has demonstrated the feasibility of using a Dowex 21K™ resin-based ion-exchange treatment system to remove chromium and selected radionuclides from Hanford Site groundwater. With the focus of the 100-HR-3 and 100-KR-4 interim actions on removal of chromium, additional bench-scale testing was recently conducted to evaluate the performance of three other resins for comparison with the Dowex 21K. The resins tested included Lewatit MP62™, ResinTech SIR-700™, and Ionac A305™. Composite groundwater samples were collected from wells in each of the two operable units to obtain a sample with a chromium concentration similar to that expected at the time of startup. However, because of the high river stage present during the months preceeding sampling, chromium concentrations were typically lower than historically observed. For the 100-HR-3 composite sample, the composite chromium concentration was 97 µg/L. For 100-KR-4, the chromium concentration was 124 µg/L.

When compared to Dowex 21K, the ResinTech SIR-700 appears capable of achieving a slightly higher quality effluent and at lower resin usage than the Dowex 21K (Table 3-2). The SIR-700 is a chromium-selective resin that may not provide any beneficial removal of co-contaminants as reported with the Dowex 21K. Additional testing alternatives and evaluation criteria to assist in selecting the resin for use are currently being studied. Information on the resin selection process will be provided to the regulatory agencies as it is developed.

The 100-HR-3 ion-exchange treatment system has been sized for a 1,515-L/min (400-gal/min) capacity. This throughput rate allows for approximately 758 L/min (200 gal/min) from the existing 100-H Area extraction wells and 758 L/min (200 gal/min) from the existing 100-D Area

wells. The planned flow rates provide flexibility to accommodate higher pumping rates or additional extraction wells, if necessary.

3.3.2 100-KR-4 Operable Unit

The 100-KR-4 Operable Unit is located approximately 10 km (6.2 mi) southwest of the 100-HR-3 GTS and will be operated independently from the 100-HR-3 pump-and-treat system. A shared treatment system for 100-HR-3 and 100-KR-4 groundwater is not practical because of the distance that separates the two sites and the presence of different co-contaminants that would require the treatment system to be operated in a "batch" mode to prevent mixing of the two groundwaters. The following subsections summarize the approach used for selecting the extraction and injection well locations.

3.3.2.1 100-KR-4 Interim Action Target Area. In the 100-K Area, the distribution of chromium in groundwater is not as well defined as at the 100-H Area. Riverbed substrate pore water sampling and groundwater sampling along the shoreline using drive points have not yet been conducted. The interim action will address a target plume area that is inferred from the available monitoring well data and the flowpath from chromium contamination emanating from the source disposal trench to the river (Figure 3-6).

3.3.2.2 100-KR-4 Groundwater Extraction System. Performance testing using step-drawdown and tests using constant rate discharge were conducted on existing wells. The results of this testing (Table 3-1) were used to support development of the numerical model and the value of parameters used for the various model runs.

Numerical modeling simulations indicate that six wells are necessary to intercept and prevent a majority of the chromium plume from discharging to the river (Figure 3-7). Actual placement of the extraction wells was based on discussion with representatives from Cultural Resources and the Indian Tribes. Many of the extraction wells had to be moved to minimize impacts to cultural resource sites.

3.3.2.3 100-KR-4 Groundwater Injection System. Because cultural resource sites occur throughout 100-KR-4, the potential impact to these sites from new well construction was balanced with the injection well criteria discussed previously. The injection area with the least impact was determined to be a site south of the 116-K-2 Trench. Injection upgradient of the trench may enhance remediation by placing this potential residual chromium source within the hydraulic area of influence of the extraction wells.

Numerical modeling results indicate three wells will be required for the 568-L/min (150-gal/min) initial flow rate from the GTS. A planned fourth well will serve as a backup, or to provide additional capacity in the event the injection wells accept less flow than predicted by the numerical modeling, or if the flow rate from the extraction system is increased above the initial estimates.

3.3.2.4 100-KR-4 Balance of Plant. The criteria for the balance-of-plant design are the same as those described for 100-HR-3, except that nominal flow rates from the extraction wells are expected to average 95 L/min (25 gal/min) with a total system throughput of 568 L/min (150 gal/min). Additional capacity to 757 L/min (200 gal/min) is available if additional wells are brought on line.

3.3.2.5 100-KR-4 Groundwater Treatment System. The design basis for the 100-KR-4 groundwater treatment system is similar to that described for 100-HR-4. The 757-L/min (200-gal/min) capacity is based on the results of numerical modeling and well performance tests with an additional 189 L/min (50 gal/min) of capacity added to provide operational flexibility.

3.3.3 Design Uncertainties

The interim action has been designed with limited hydrogeologic and chromium distribution data, especially for the 100-D Area and the 100-KR-4 Operable Unit. Potential uncertainties that could impact performance of the 100-HR-3 and 100-KR-4 pump-and-treat systems and proposed contingency actions are described in the following subsections.

3.3.3.1 Hydrogeologic Conditions. No long-term pumping tests were conducted in the 100-D Area and 100-KR-4 Operable Unit to determine sustainable well yields or to identify boundary conditions that could limit extraction well effectiveness. Initial pumping rates used for numerical modeling were estimated from short-term tests conducted in wells designed for groundwater monitoring. This limitation may yield erroneous estimates of well drawdown, hydraulic conductivity, and capture zone width, thus resulting in a deficient well spacing. Typical response actions include higher pumping rates if sufficient pump and well capacity exists or adding additional wells to the groundwater extraction system. In the event that additional extraction wells are necessary, new wells to be installed for interim action monitoring have been designed to serve as extraction wells. Conversion of new monitoring wells to extraction wells would require installation of pumps and piping and adjustments to system controls.

Heterogeneities in the aquifer matrix, not detected during the limited field investigation, will become evident during remediation. Heterogeneities will most likely be manifested by well drawdowns that exceed estimated values, capture zone extents smaller than those predicted by numerical modeling, and/or anomalous contaminant concentration trends.

Hydraulic channeling of river water could also reduce the size of the capture zone in near-river extraction wells. Conservative pumping rates were modeled for these wells to reduce the possibility of this condition occurring. However, unknown zones of highly permeable gravel and cobbles are a likely occurrence and may result in hydraulic short circuiting that will limit the effectiveness of these wells. A possible response action for this condition would be to reduce the pumping rate in affected wells, pump unaffected wells at a higher rate, or connect other near-river monitoring wells to the extraction network.

3.3.3.2 Feasibility of Using Injection Wells. Limited information is available on the long-term feasibility of using wells to inject water in the 100 Area. Data used to support the injection well design consist of an 80-minute, 189-L/min (50-gal/min) test conducted at well H4-48, which produced a groundwater elevation increase of 1.5 m (4.8 ft) in the well. Historical observations made during operation of the retention basins have also demonstrated the ability of the Hanford formation to accept large volumes of water.

The number of injection wells and their spacing is based solely on the results of numerical modeling and professional judgment. Injection well performance will be assessed using water level monitoring data collected during the startup and operation phase. These data will be used to develop guidelines for long-term operation and to confirm the final number of wells necessary to support interim action operations.

Injection wells will be constructed in areas with limited information on geology or water quality conditions. If during well installation and development the hydrogeologic characteristics of the formation or presence of contaminants do not meet design criteria, additional wells or an alternate location may have to be considered.

3.3.3.3 Variable River Stage. The hydrogeologic design basis used the average river stage conditions present between January 1994 and August 1995. Extended periods of above-average or below-average river stage are expected to impact the performance of near-river wells. Above-average river stage will extend the zone of riverbank storage further inland resulting in a higher proportion of the well flow originating from the river and a reduction in the concentration of chromium produced from the well. A possible response action for this condition would be a reduction in the pumping rate of affected wells or shutting down affected well(s) on a temporary basis until the condition passes. Alternatively, if continued pumping promotes flushing of the aquifer between the extraction well(s) and the river and continued pumping can be performed without impacting treatment effectiveness, the well(s) may continue to be operated.

Extended periods of below-average river stage may result in a temporary hydraulic gradient increase in the region adjacent to the river, thus decreasing the size of the capture zone. A possible response action for this condition would be to temporarily increase the pumping rate to compensate for the condition.

3.3.3.4 Spatially Variable Chromium Distribution. The conceptual model for 100-HR-3 and 100-KR-4 assumes a homogeneous horizontal and vertical distribution within the unconfined aquifer. Variations in the hydraulic conductivity of the aquifer matrix often result in preferential migration of chromium through the higher conductivity zones. These zones respond rapidly to remediation and cleanup faster than the low-permeability zones that "bleed" contaminants into the higher conductivity zones over extended time periods. This condition is often manifested by an asymptotic concentration trend or an increase in concentrations once the pump-and-treat system is shut off. A typical response action for this condition is to operate the pump-and-treat system in a cyclic manner to increase the mass of chromium removed per gallon of water extracted.

3.4 GENERAL DESCRIPTION AND OPERATION OF THE PUMP-AND-TREAT SYSTEM

The 100-HR-3 and 100-KR-4 pump-and-treat systems will use a series of extraction wells, equipped with submersible pumps, to draw groundwater from the unconfined aquifer. Extracted groundwater will be conveyed through aboveground piping to a collection tank(s) where it will be combined with water from the other extraction wells. From the collection tank(s), the water will be pumped to an enclosed treatment system where chromium will be removed by ion exchange. Treated groundwater will be transferred through an aboveground pipe to the injection well network.

3.4.1 Groundwater Extraction System

In the 100-H Area, the groundwater extraction system consists of five existing wells, three located along the river (H4-11, H4-12A and H4-15A) and two (H4-7 and H3-2A) extending inland along a line perpendicular to the river (see Figure 2-1). Each well is 152 mm (6 in.) in diameter with a total depth ranging from 12.8 m (42 ft) (H4-15A) to 16.2 m (53 ft) (H4-7). The wells are constructed with 4.5-m- (15-ft) long stainless steel, 20-slot well screens with stainless steel riser casing. Each well screen straddles the full saturated thickness of the aquifer. The initial pumping rates of the near-river extraction wells are 38 L/min (10 gal/min), 76 L/min (20 gal/min) for H4-7, and 151 L/min (40 gal/min) for H3-2A.

The groundwater extraction system in the 100-D Area consists of two existing wells: D8-53 and D8-54A (see Figure 2-6). Each well is 101 mm (4 in.) in diameter with a total depth of 19.8 and 22 m (65 and 72 ft), respectively. The wells are constructed with 6.1-m- (20-ft) long stainless steel, 10-slot well screens with stainless steel riser casing. The well screen straddles the full saturated thickness of the aquifer. Initial extraction rates are estimated to be at 151 L/min (40 gal/min) from each well.

The groundwater extraction system in 100-KR-4 will consist of six new wells (see Figure 2-11). Each well will be 152 mm (6 in.) in diameter with a total depth estimated between 19.8 and 24.4 m (65 and 80 ft). The wells will be constructed with 13.7-m (45-ft) well screens with the slot size determined from sieve analysis.

Extraction wells will be equipped with electric, adjustable frequency drive submersible pumps, pressure transducers for water level monitoring, high-low set points for pump on-off control, high-pressure shutoff sensors, sample ports, and inline flow sensors. A return pipe at each well (Figures 3-8a and 3-8b) will allow water from the conveyance pipe to drain back into the well in the event of system shutdown.

The initial concentration of chromium from the 100-HR-3 extraction system is expected to be 223 μg/L with a potential maximum concentration of 265 μg/L (Table 3-3). At 100-KR-4, the initial chromium concentration is estimated at 114 μg/L. These concentration estimates are

based on data obtained between January 1994 and August 1995. The actual concentrations observed will reflect chromium concentrations and groundwater flow conditions present during startup.

3.4.2 Groundwater Injection System

The 100-HR-3 treated groundwater injection system includes three new wells located in a triangular array approximately 100 m (109 yd) apart. Each well will be 152.4 mm (6 in.) in diameter with an estimated depth between 18.3 and 21.4 m (60 and 70 ft). The wells will have 9.1-m (30-ft) screens with 6.1 m (20 ft) extending below the water table and 3 m (10 ft) above. Initially, two wells will be used to inject treated groundwater into the unconfined aquifer. The third well will serve as a backup or will provide additional capacity if extraction system throughput is increased. Water will be injected through a perforated pipe, 76 mm (3 in.) in diameter, which extends below the ambient water table (see Figure 3-8a). Initial injection rates are estimated to be 322 L/min (85 gal/min) per well.

The 100-KR-4 treated groundwater injection system will consist of four wells located in a linear northeast-southwest alignment on the south side of the trench. Each well will have an estimated depth of 30.5 m (100 ft). The wells will have 9.1-m (30-ft) well screens with 6.1 m (20 ft) extending below the water table and 3 m (10 ft) above (see Figure 3-8b). The fourth well will serve as a backup or will provide additional capacity if the extraction system throughput is increased. The water will be injected in the same manner as 100-HR-3 at an estimated rate of 189 L/min (50 gal/min) per well.

3.4.3 Balance of Plant

The balance of plant will include all control systems, piping, valves, pumps, and electrical and mechanical equipment that enables groundwater from the extraction wells to be conveyed to the treatment system and returned to the injection wells for injection back into the aquifer.

The pump-and-treat systems have been designed to run with minimal operator attention. This capability results from the use of programmable logic controllers (PLCs) that receive and transmit electronic signals to and from the field control devices. These data are also transmitted via telemetry to the primary operator interface computer (OIC) where they can be viewed by the operator, and system adjustments performed if necessary. The following subsections provide additional information on the various components of the pump-and-treat system.

The OIC will be located in the treatment system building and represents the primary link between the operator and the pump-and-treat system. From the OIC the operator can view all tank levels, pump status and flow rates, pumping water levels, and alarm status. The OIC is also the interface for starting/stopping the pumps and selecting extraction well flow rates. The OIC also serves as a data storage and retrieval device and will be configured so that system status can be viewed via a laptop computer from offsite locations.

Groundwater from the 100-HR-3 extraction wells will be conveyed through 38- to 100-mm- (1.5- to 4-in.) diameter high-density polyethylene (HDPE) pipe to 34,826-L (9,200-gal) storage tanks. One tank located in the 100-H Area will collect water from the near-river extraction wells and H4-7, while the second tank will collect water from the two 100-D Area extraction wells (Figure 3-9a). Groundwater from the 100-D collection tank (Transfer Pump Building) will be pumped approximately 3,900 m (4,266 yd) through one of two parallel 100-mm (4-in.) HDPE pipes to the 11,356-L (3,000-gal) GTS influent tank located inside the 1713-H Building (Figure 3-9b).

Groundwater from the 100-KR-4 extraction wells will also be conveyed through aboveground HDPE pipe to centrally located collection tanks for feed into the GTS influent tank (Figure 3-9c).

3.4.4 Groundwater Treatment System

The 100-HR-3 GTS will consist of four 379-L/min (100-gal/min) modular ion-exchange units with four columns per unit (Figure 3-10). Groundwater will be pumped from the 11,356-L (3,000-gal) influent storage tank located inside the 1713-H Building to a manifold system that distributes the water in 379-L/min (100-gal/min) increments to the ion-exchange units. Within each modular unit, individual columns will be operated in a lead, lag, and polishing series configuration. Groundwater enters the lead column, passes through the lag column, then to the polishing column. Once the effluent concentration from the polishing column nears the desired treatment level, the columns are moved up in the series, with the lead column rotated to the standby position for resin changeout and the standby column brought on as the new polishing column. Treated groundwater will be pumped to a 11,356-L (3,000-gal) effluent tank for distribution to the injection wells.

Each of the 379-L/min (100-gal/min) modular units will be operated in this manner. Sample ports located between the columns and inline chromium monitors located on the influent and effluent sides of the treatment system will be used for monitoring treatment system performance and determining when resin changeout is required.

The 100-KR-4 treatment system will be similar, but will consist of two 379-L/min (100-gal/min) modular units. Both GTSs have influent and effluent filters to remove suspended particulate matter 25 microns in size and larger.

The 100-HR-3 GTS will be located inside an existing building (1713-H), which has been renovated for use at significantly less cost than purchasing a new building. The 100-KR-4 GTS will be placed inside a new metal building insulated for weather protection.

Process residuals from the ion-exchange systems will consist of spent resin that will be dewatered and placed in a disposal container. Liquids will be returned to the influent collection tank for treatment. Spent resin is not expected to exceed the toxicity characteristic leaching procedure (TCLP)-chromium reference level and will be transported to the Environmental Restoration Disposal Facility (ERDF) for disposal. Additional information on the management

and testing of spent resin prior to disposal is presented in Chapter 5.0 of this document and will be presented in an Operations Waste Management Plan.

3.4.4.1 Ion-Exchange Modules. The interconnecting piping will be configured to allow series flow through three or four vessels with any of the vessels as the first (or lead) vessel. Design service flow rate through each module will be 380 L/min (100 gal/min) with service flow direction downward through each vessel. At design service flow rate, pressure drop across four vessels in series will not exceed 276 kPa (40 lb/in^2) with water at 1.7 to 26.7 °C (35 to 80 °F). Valves for aligning the vessels in different operating configurations will be manually operated. Each vessel will be equipped with a relief valve discharging to a common return header. Each module outlet pipe will be equipped with a manually operated valve for flow balancing.

3.4.4.2 Resin Loading System. The resin loading/removal system has been designed to allow the treatment system to continue operating during routine changeout procedures. The resin loading system will use treated water (from tank T-H02) to sluice (slurry) fresh resin into any vessel using a common transport header. Excess sluice water will be simultaneously removed from each vessel and returned to the process system (to tank T-H01). The resin loading system has been designed to minimize labor in emptying/sluicing fresh resin supplied in 0.14-m^3 (5-ft^3) fiber containers. Compressed air will not be used for any phase of resin loading.

3.4.4.3 Resin Removal and Dewatering System. Treated water (from tank T-H02) will be used to sluice exhausted resin from any vessel to a dewatering device using a common transport header. The dewatering device will have a porous surface to retain exhausted resin and fines. Water removal will be by gravity drainage. Resin removal from the dewatering device will be performed by the operators. Drained water from the dewatering device will be returned to the process system (to tank T-H01). Components of the resin removal/dewatering system will be protected from unsafe operating conditions (overflowing, running dry, etc.) by automatic protective features. The use of a PLC to control system functions will be considered. Compressed air will not be used for any phase of resin removal or dewatering.

3.4.4.4 Backwash System. Treated water (from tank T-H02) will be used to backwash (expand by 50%) any ion-exchange vessel resin bed. Backwash water from any ion-exchange vessel will return to tank T-H01 via a common header equipped with a screened trap. The backwash system may be an integral part of the systems described in Sections 3.4.4.2 and 3.4.4.3. Compressed air will not be used in any phase of resin backwash.

3.4.4.5 Resin Type. The type of resin used in each of the groundwater treatment systems will be periodically evaluated for performance and cost effectiveness. During the course of the interim action, changing groundwater characteristics, resin availability and cost, or development of new resins may justify a change in the resin used. Prior to changing the resin type, supporting information will be provided to the regulatory agencies to demonstrate the basis for the change.

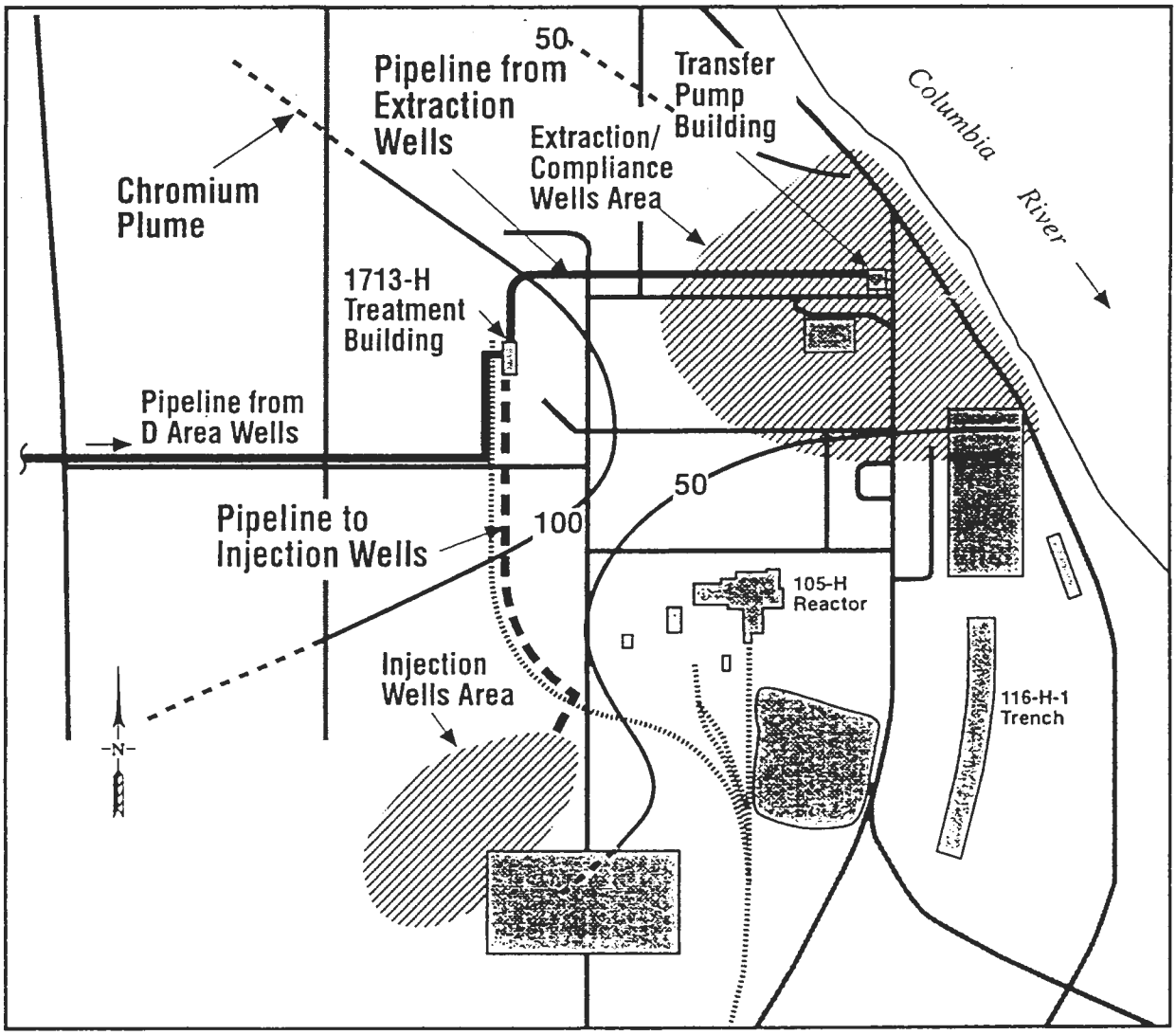
3.4.5 System Monitoring and Shutoff Devices

The pump-and-treat system will include a number of devices designed to detect typical system upsets. To protect against tank overflows, high-level sensors are located in each collection tank. These sensors will shut down extraction wells when the high-level set point is exceeded. Leakage from pipe/joint failures can be detected by flow sensors that shut down the appropriate extraction well if the flow in the line drops below the low-flow set point. Blocked conveyance piping will be detected by high-pressure shutoff switches. Water level drawdown will be monitored by a sensor that shuts the pump off if the water level drops below the low-level set point.

A relatively constant groundwater temperature of 10 to 13 °C (50 to 55 °F) is expected to provide sufficient freeze protection under normal operating and weather conditions. During extreme conditions, drainage of extraction and injection well piping between the transfer pump building and the wells will occur automatically once the system is shut down. External polyvinyl chloride piping and the collection tanks will be heat traced and the GTS buildings heated and insulated.

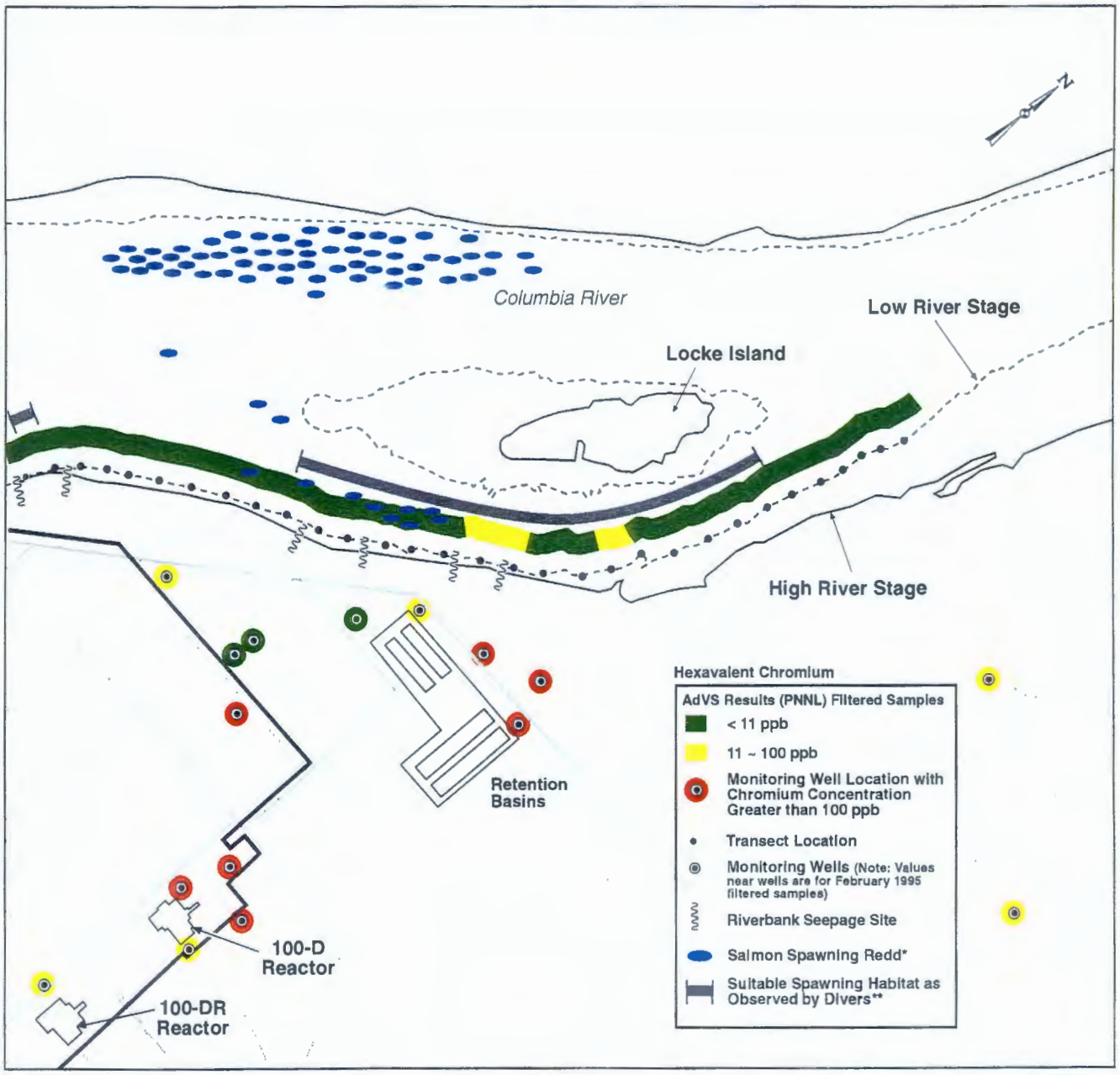
Under normal operating and average winter weather conditions, freezing of the HDPE piping between the 100-D and 100-H Areas is not expected to occur. In the unlikely event that extreme conditions did result in freezing of water inside the pipe, the pipe would not incur any freeze-related damage. Some loss of pipeline efficiency or use may occur until the line thaws. Air and drain valves have been placed at selected high- and low-elevation points that enable the pipeline to be drained manually if desired. Conditions and procedures for draining of the line will be presented in the Operations and Maintenance Plan.

Figure 3-1. 100-H Target Area.



E9604075.12b

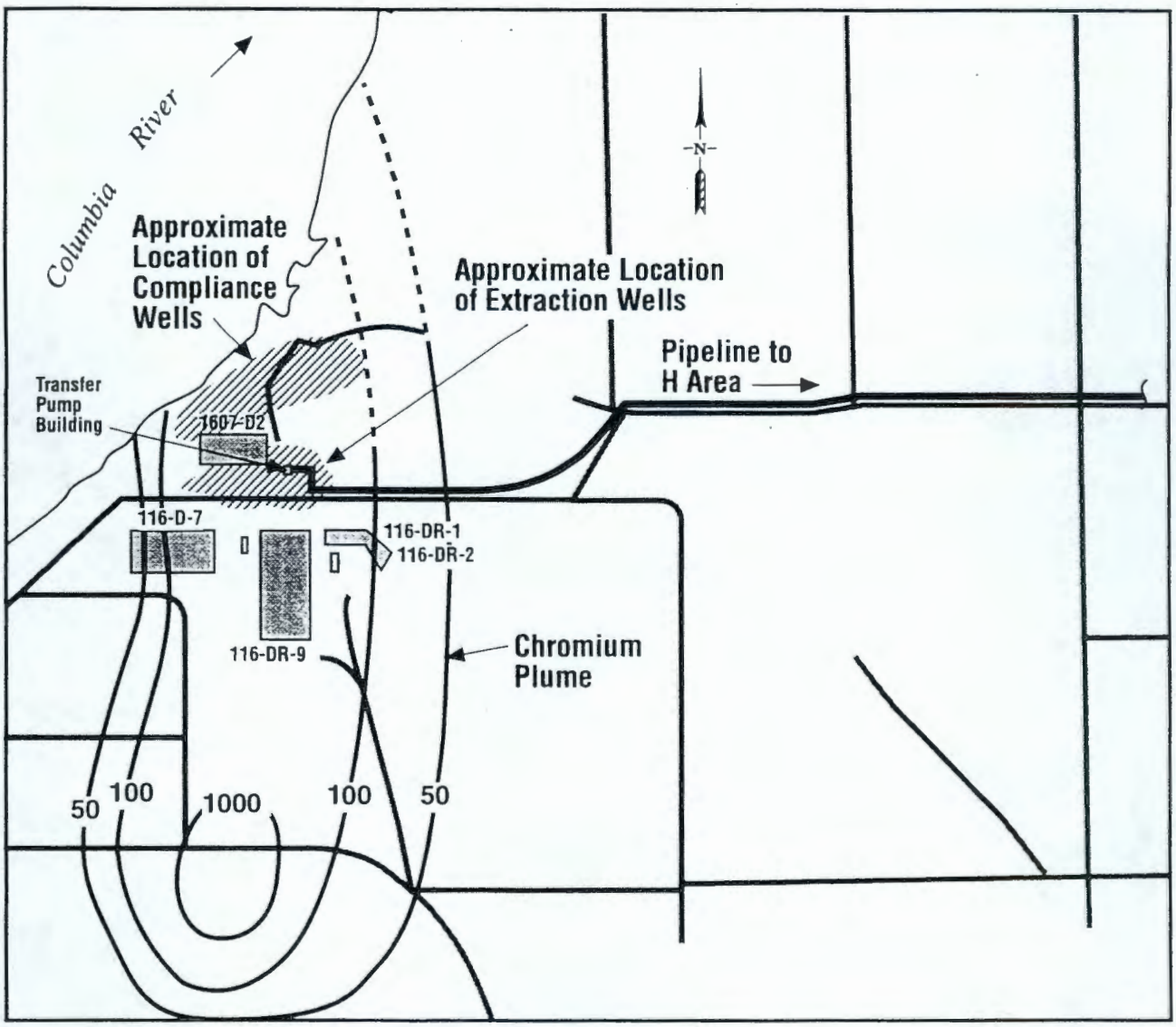
Figure 3-2. Chromium Distribution in Riverbed Sediment Pore Water Adjacent to 100-D Interim Action Target Area.



*Fall Chinook Salmon Redds
Aerial Photo Locations from 1991 (Approximate)

**Suitable Spawning Gravels Based on Grain Size Distribution
(i.e., Ratio of Boulders, Cobble, Gravel, Sand/Silt and Embeddedness)

Figure 3-3. 100-D Target Area.



E9604075.11b

Figure 3-4. 100-H Area Modeling Results.

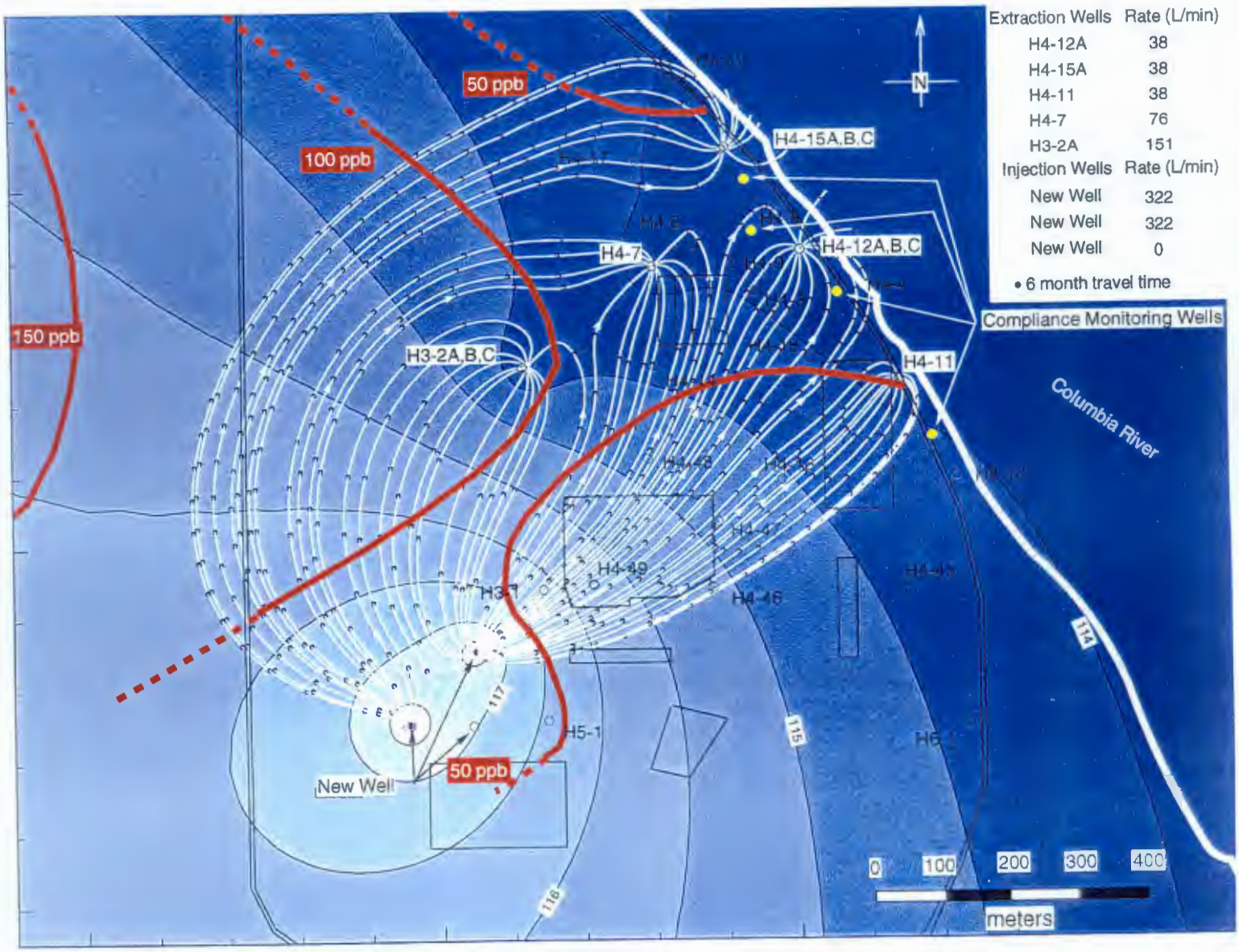


Figure 3-5. 100-D Area Modeling Results.

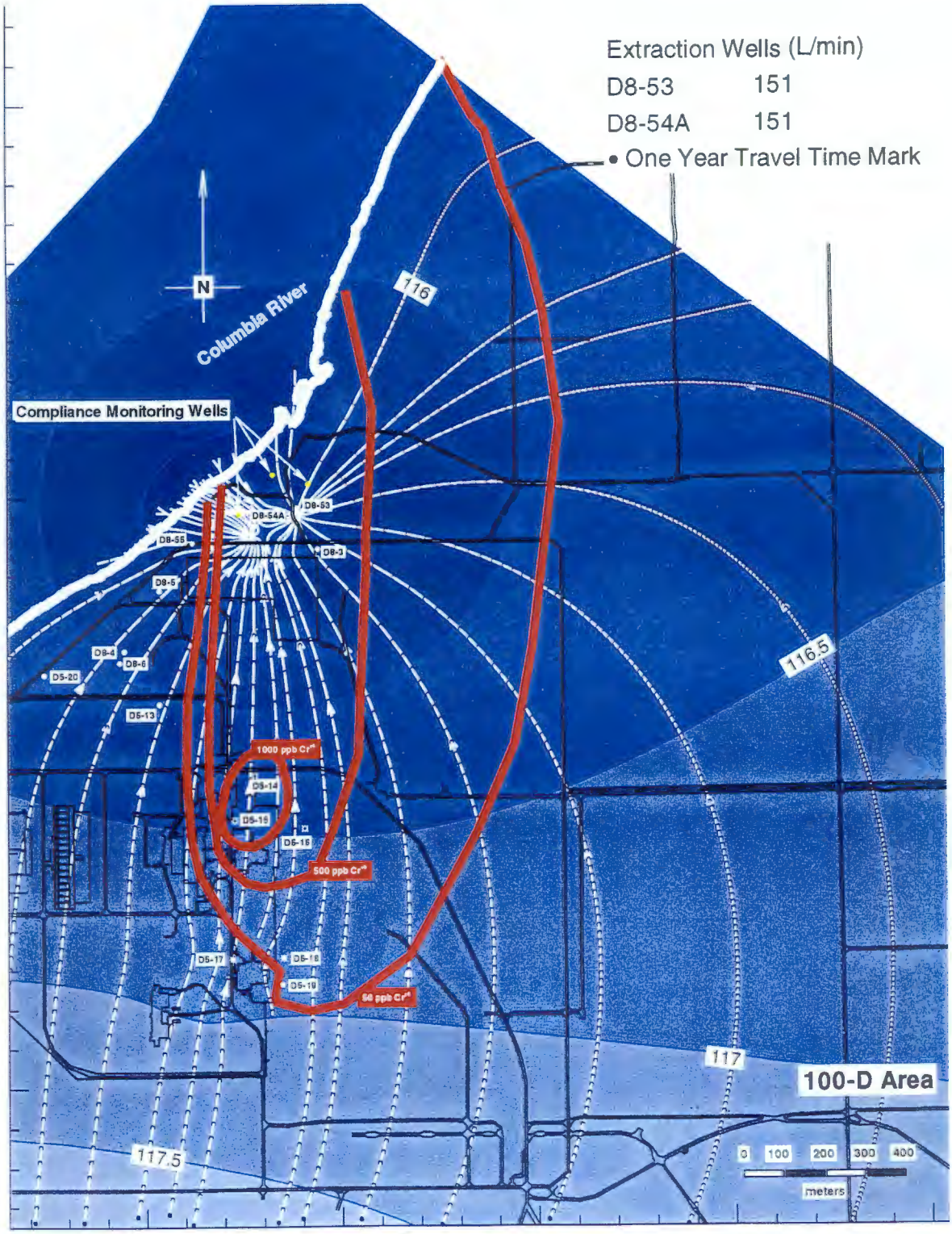
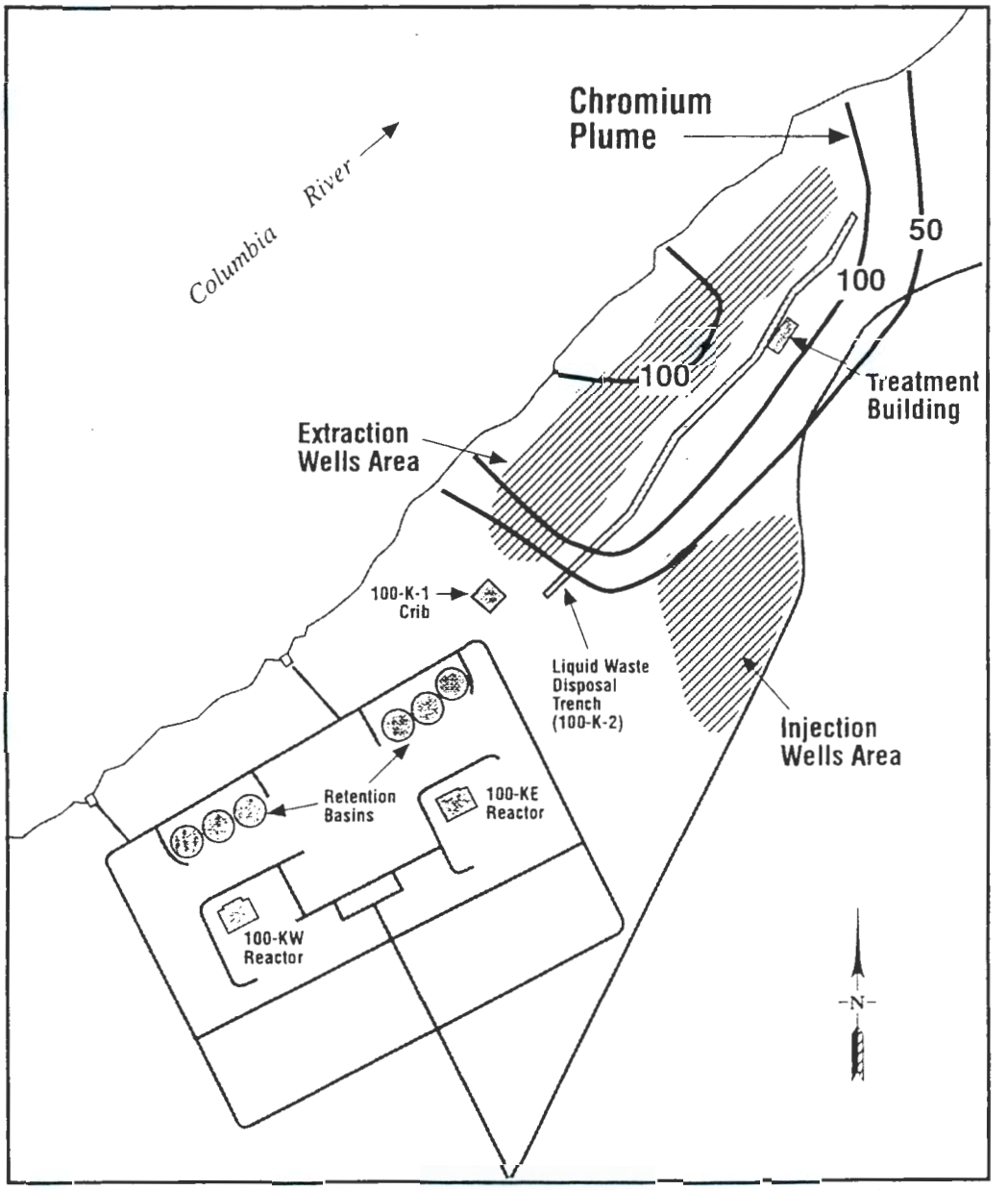
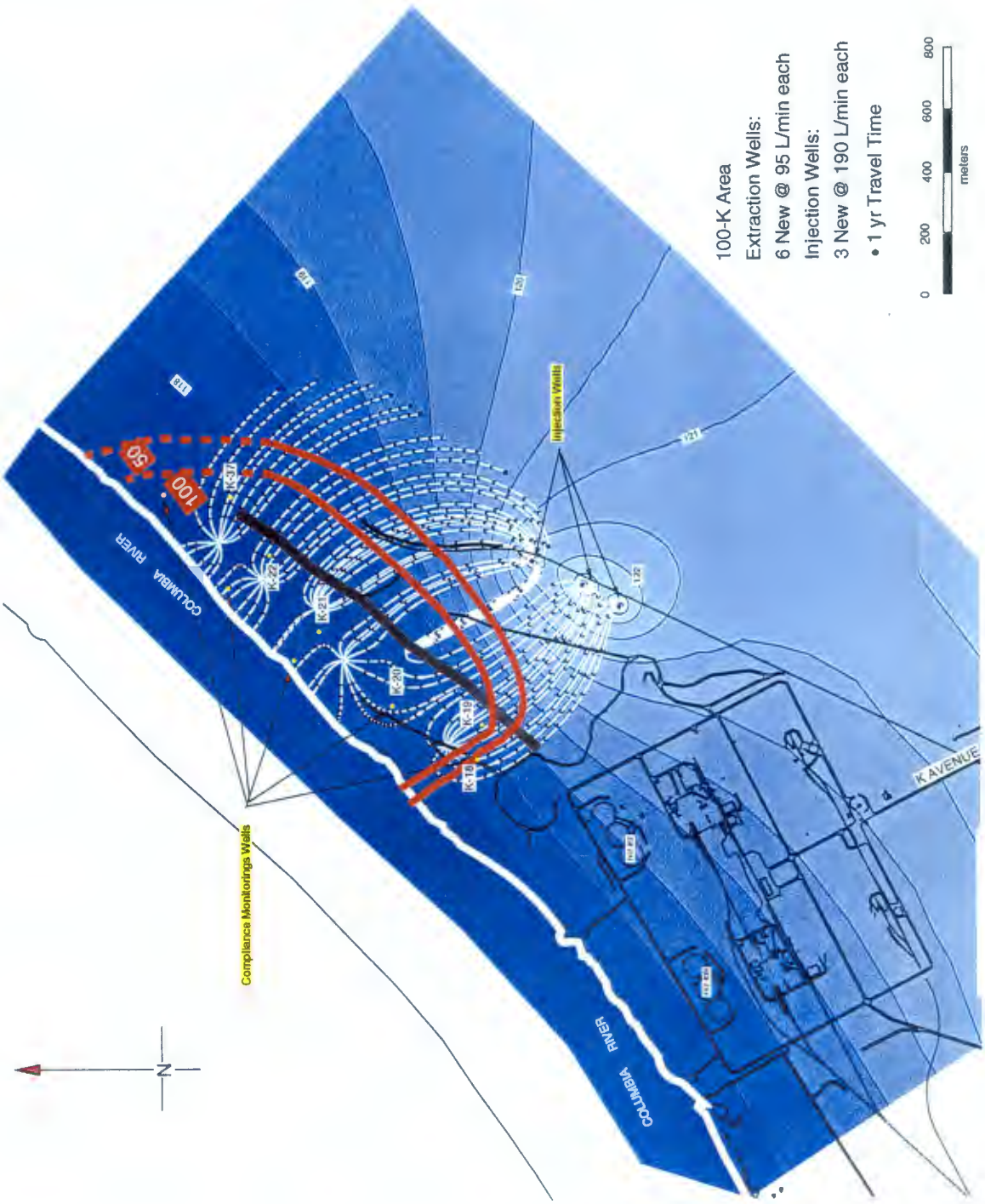


Figure 3-6. 100-K Target Area.



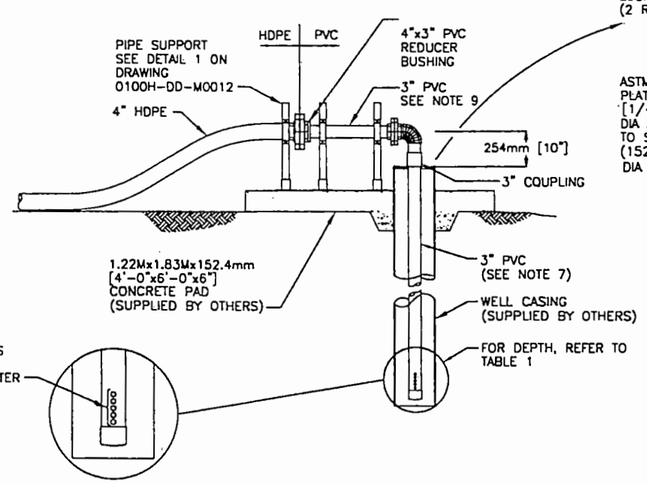
E9604075.13b

Figure 3-7. Recommended Extraction and Injection Well Scenario for 100-KR-4.



9713506.1913

DRAWING NO.	REV. NO.
0100H-DD-M0008	0



TYPICAL INJECTION WELL HEAD
SCALE: NTS

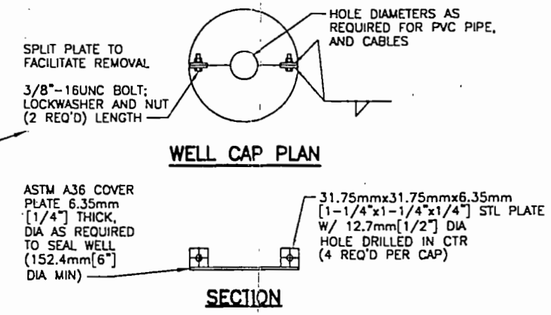
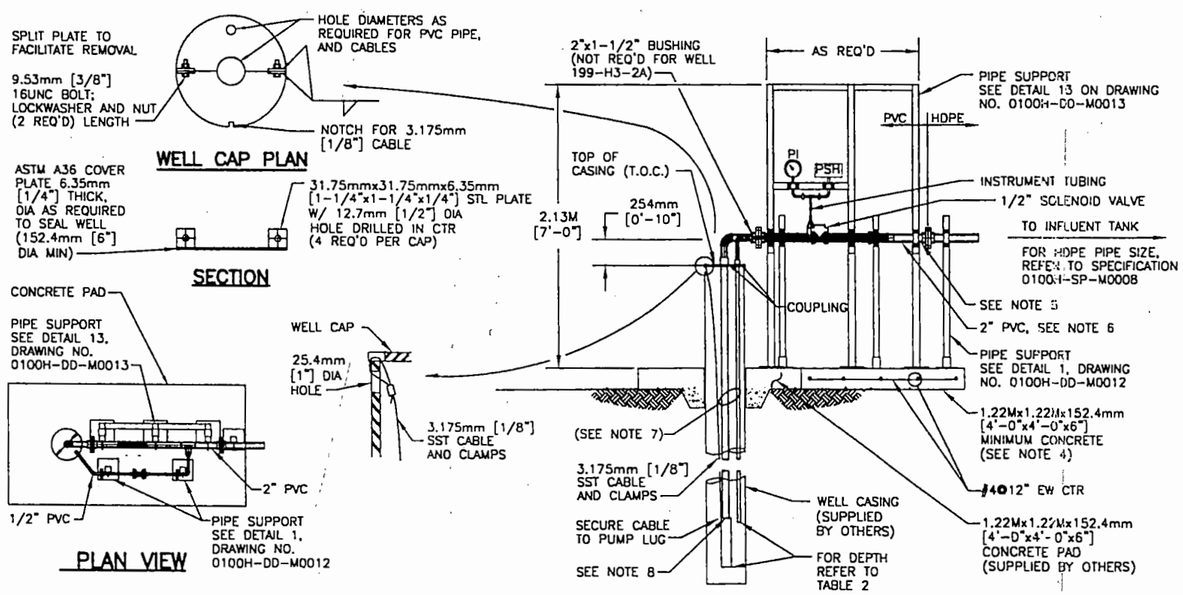


TABLE 1		
WELL NO.	WELL DEPTH	DISCHARGE PIPE
199-H3-3	19.20M[63 FT]	18.59M[61 FT]
199-H3-4	20.12M[66 FT]	19.51M[64 FT]
199-H3-5	21.34M[70 FT]	20.73M[68 FT]

NOTES

1. WELL PUMP SHALL BE INSTALLED IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS AND SPECIFICATION NO. 0100H-SP-M0002.
2. SEE DRAWING NO. 0100H-DD-M0014 FOR ABBREVIATIONS AND SYMBOLS.
3. NOMINAL DIMENSIONS ARE SHOWN TO ILLUSTRATE GENERAL LAYOUT.
4. PROVIDE ADDITIONAL CONCRETE. SURFACE OF CONCRETE SHALL MATE WITH EXISTING CONCRETE PAD.
5. REDUCE AS REQUIRED FOR HDPE SIZE.
6. HEAT TRACE AND INSULATE ALL PVC ABOVE T.O.C., SOLENOID VALVE, INSTRUMENT TUBING AND PRESSURE SWITCH. HEAT TRACE AND INSULATE PUMP DISCHARGE PIPE FROM T.O.C., 1.83M [6 FEET] INTO WELL.
7. ALL PVC PIPE FITTINGS INSTALLED BELOW T.O.C. SHALL BE THREADED.
8. INSTALL REDUCER BUSHINGS (WHERE APPROPRIATE) TO MATCH PUMP DISCHARGE WITH THE DISCHARGE PIPE DIAMETER SHOWN IN TABLE 2.
9. HEAT TRACE AND INSULATION IS NOT REQUIRED FOR INJECTION WELL PVC.

PRELIMINARY



TYPICAL EXTRACTION WELL HEAD
SCALE: NTS

TABLE 2				
WELL NO.	DEPTH TO BOTTOM OF PUMP	RETURN PIPE DEPTH	WELL CASING DIA.	PUMP DISCHARGE PIPE DIA.
199-D8-53	16.15M[53.0 FT]	9.14M[30.0 FT]	4 IN	1-1/2 IN
199-D8-54A	15.39M[50.5 FT]	9.14M[30.0 FT]	4 IN	1-1/2 IN
199-H4-07	16.15M[53.0 FT]	9.14M[30.0 FT]	6 IN	1-1/2 IN
199-H4-11	15.39M[50.5 FT]	9.14M[30.0 FT]	6 IN	1-1/2 IN
199-H4-12A	14.63M[48.0 FT]	9.14M[30.0 FT]	6 IN	1-1/2 IN
199-H4-15A	12.19M[40.0 FT]	9.14M[30.0 FT]	6 IN	1-1/2 IN
199-H3-2A	14.78M[48.5 FT]	9.14M[30.0 FT]	6 IN	2 IN

DEPTHS SHOWN T.O.C.

RECORD INFORMATION

RECORD NO.	BLDG NO.	INDEX NO.
H-1-81053 Sht 1	100H	9901

ERIC ANDREW NELSON
STATE OF WASHINGTON
32867
PROFESSIONAL ENGINEER
EXPIRES:

REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CH'K	ORIG/ ENG'R	ENG'R CH'K	G./TEL APPROV	SH. MGR. ENG'R
0	6/17/96	ISSUED FOR CONSTRUCTION	AWK					

SCALE: AS SHOWN

U.S. DEPARTMENT OF ENERGY
DOE FIELD OFFICE, RICHLAND
HANFORD ENVIRONMENTAL RESTORATION PROGRAM

BECHTEL HANFORD INC. RICHLAND, WASHINGTON | CH2M HILL HANFORD, INC. RICHLAND, WASHINGTON

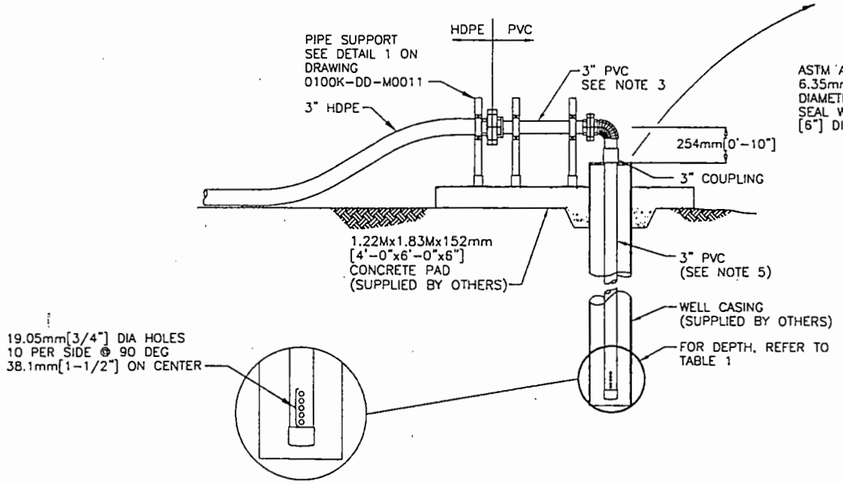
Figure 3-8a. 100-HR-3 Typical Extraction and Injection Well Head Details.

BECHTEL JOB NO.	DOE CONTRACT NO.	CADD FILENAME
22192	DE-AC06-93RL12367	1HDM0008.DWG

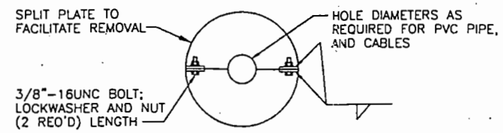
HANFORD	TASK	DRAWING NO.	REV. NO.
	100H	0100H-DD-M0008	0

9713506.1914

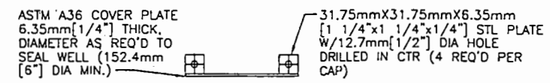
DRAWING NO.	REV. NO.
0100K-DD-M0007	0



TYPICAL INJECTION WELL HEAD
SCALE: NTS

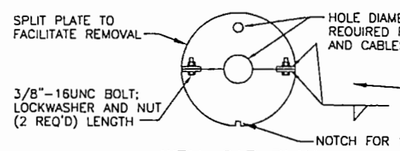


WELL CAP PLAN

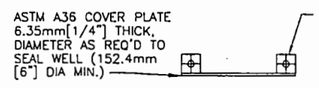


SECTION

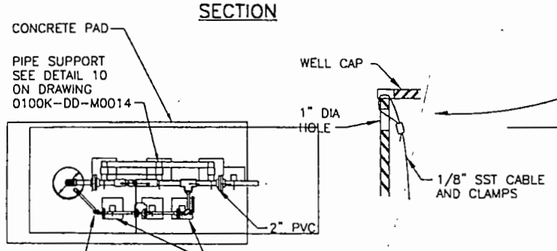
TABLE 1		
WELL NO.	WELL DEPTH	DISCHARGE PIPE
199-K-121A	28.04M [92 FT]	27.43M [90 FT]
199-K-122A	28.95M [95 FT]	28.35M [93 FT]
199-K-123A	28.95M [95 FT]	28.35M [93 FT]
199-K-124A	29.26M [96 FT]	28.65M [94 FT]



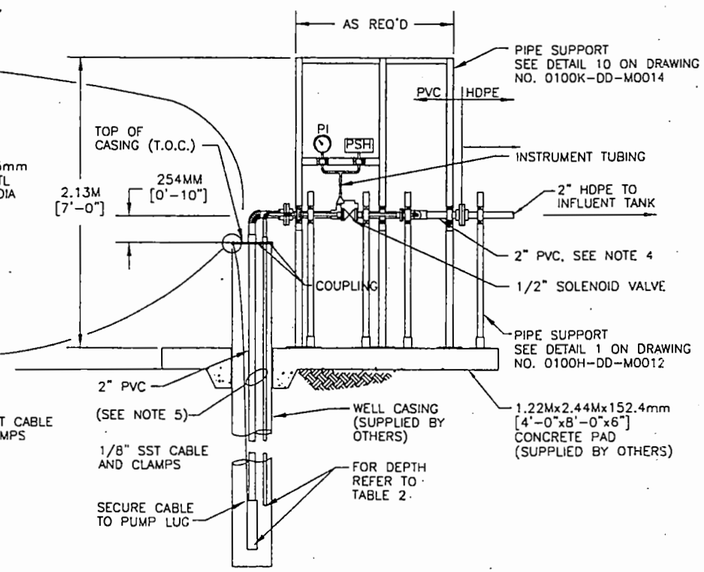
WELL CAP PLAN



SECTION



PLAN VIEW



TYPICAL EXTRACTION WELL HEAD
SCALE: NTS

TABLE 2			
WELL NO.	DEPTH TO BOTTOM OF PUMP	RETURN PIPE DEPTH	WELL CASING DIA.
199-K-113A	19.20M [63 FT]	9.14M [30 FT]	152.4mm [6 IN.]
199-K-115A	19.20M [63 FT]	9.14M [30 FT]	152.4mm [6 IN.]
199-K-116A	22.55M [74 FT]	9.14M [30 FT]	152.4mm [6 IN.]
199-K-118A	22.55M [74 FT]	9.14M [30 FT]	152.4mm [6 IN.]
199-K-119A	28.95M [95 FT]	9.14M [30 FT]	152.4mm [6 IN.]
199-K-120A	17.98M [59 FT]	9.14M [30 FT]	152.4mm [6 IN.]

DEPTHS SHOWN T.O.C.

NOTES

DOE/RL-96-84
Rev. 0

1. WELL PUMP SHALL BE INSTALLED IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS.
2. SEE DRAWING NO. 0100K-DD-M0001 FOR ABBREVIATIONS AND SYMBOLS.
3. NOMINAL DIMENSIONS ARE SHOWN TO ILLUSTRATE GENERAL LAYOUT.
4. HEAT TRACE AND INSULATE ALL PVC ABOVE T.O.C., SOLENOID VALVE, INSTRUMENT TUBING, PRESSURE INDICATOR AND PRESSURE SWITCH. HEAT TRACE AND INSULATE PUMP DISCHARGE PIPE FROM T.O.C., 6 FEET INTO WELL.
5. ALL PVC PIPE FITTINGS INSTALLED BELOW T.O.C. SHALL BE THREADED.
6. HEAT TRACE AND INSULATION IS NOT REQUIRED FOR INJECTION WELLS.

PRELIMINARY

ERIC ANDREW NELSON, STATE OF WASHINGTON, 32867, REGISTERED PROFESSIONAL ENGINEER
EXPIRES:

REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CK'K	ORIG/ ENG'R	ENG'R CK'K	CL/TEL APPROV	BA PROJ ENG'R
0	6/27/96	ISSUED FOR CONSTRUCTION	CJB					

SCALE: AS SHOWN

U.S. DEPARTMENT OF ENERGY
DOE FIELD OFFICE, RICHLAND
HANFORD ENVIRONMENTAL RESTORATION PROGRAM

BECHTEL HANFORD INC. RICHLAND, WASHINGTON | CH2M HILL HANFORD INC. RICHLAND, WASHINGTON

Figure 3-8b. 100-KR-4 Typical Extraction and Injection Well Head Details.

BECHTEL JOB NO.	DOE CONTRACT NO.	CADD FILENAME
22192	DE-AC06-93RL12367	1KDM0007.DWG

HANFORD	TASK	DRAWING NO.	REV. NO.
	100K	0100K-DD-M0007	0

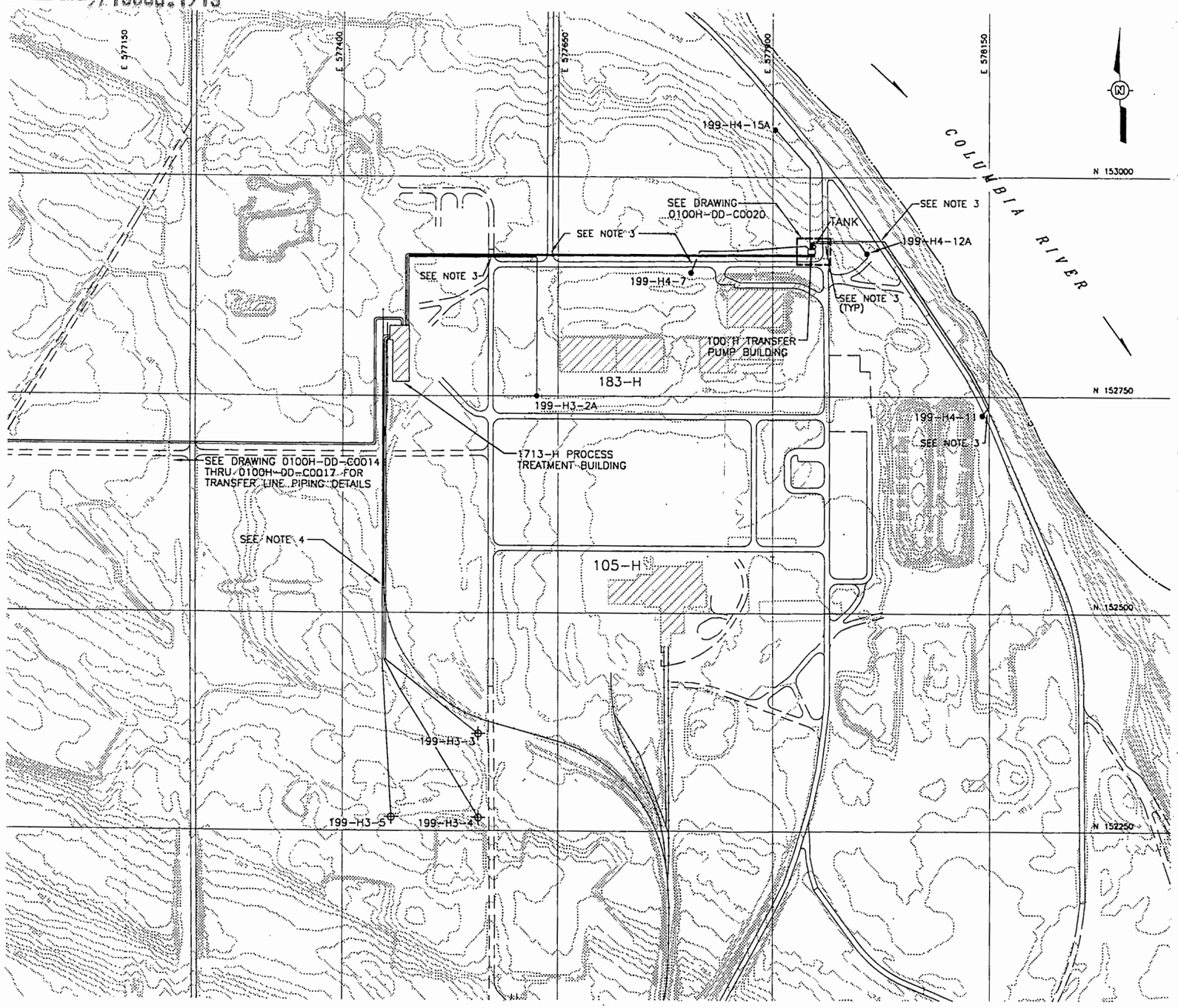
BECH-4/95

RECORD INFORMATION

RECORD NO.	BLDG NO.	INDEX NO.
H-1-81443 Sht 1	100K	9901

DRAWING NO.	REV. NO.
0100H-DD-C0013	0

9713506.1915



SCALE 1:2000
20 0 20 40 60 METERS
1 cm = 20 meters

RECORD INFORMATION

RECORD NO.	BLDG NO.	INDEX NO.
H-1-81330 Sht 1	100H	8001

NOTES

DOE/RL-96-84
Rev. 0

1. APPROXIMATE PIPE ROUTINGS ARE SHOWN. PIPING ROUTE SHALL BE FIELD LOCATED.
2. ALL PIPE SHALL BE LAID ON GROUND SURFACE.
3. SEE DRAWING 0100H-DD-C0022 FOR TYPICAL PIPE ROAD CROSSING DETAIL.
4. REMOVE ONE RAIL FOR INJECTION PIPING WHERE NECESSARY TO CROSS TRACKS.

REFERENCE:

BASE MAP TAKEN FROM 100D AND 100H TOPOGRAPHIC MAPPING, DRAWING NO'S H-13-000127, H-13-000133, H-13-000134, H-13-000141, AND H-13-000142. HORIZONTAL DATUM: NAD-83 LAMBERT PROJECTION. VERTICAL DATUM: NATIONAL GEODETIC SURVEY DATUM, NGVD29, AS PROVIDED BY KAISER ENGINEERS-HANFORD.

PRELIMINARY

JOSEPH A. GAUTIER, STATE OF WASHINGTON, 15923, REGISTERED PROFESSIONAL ENGINEER
EXPIRES:

REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CK'D	DRG/ ENG'R	ENG'R CK'D	CL/TCL APPROV	QA PROJ ENG'R
0	5/27/96	ISSUED FOR CONSTRUCTION	TLC					

SCALE AS SHOWN

U.S. DEPARTMENT OF ENERGY
DOE FIELD OFFICE, RICHLAND
HANFORD ENVIRONMENTAL RESTORATION PROGRAM

BECHTEL HANFORD INC. RICHLAND, WASHINGTON | CH2M HILL HANFORD INC. RICHLAND, WASHINGTON

Figure 3-9a. 100-HR-3 100-H Area Conveyance Piping Layout.

BECHTEL JOB NO.	DOE CONTRACT NO.	CADD FILENAME
22192	DE-AC06-93RL12367	1HDC0013.DWG

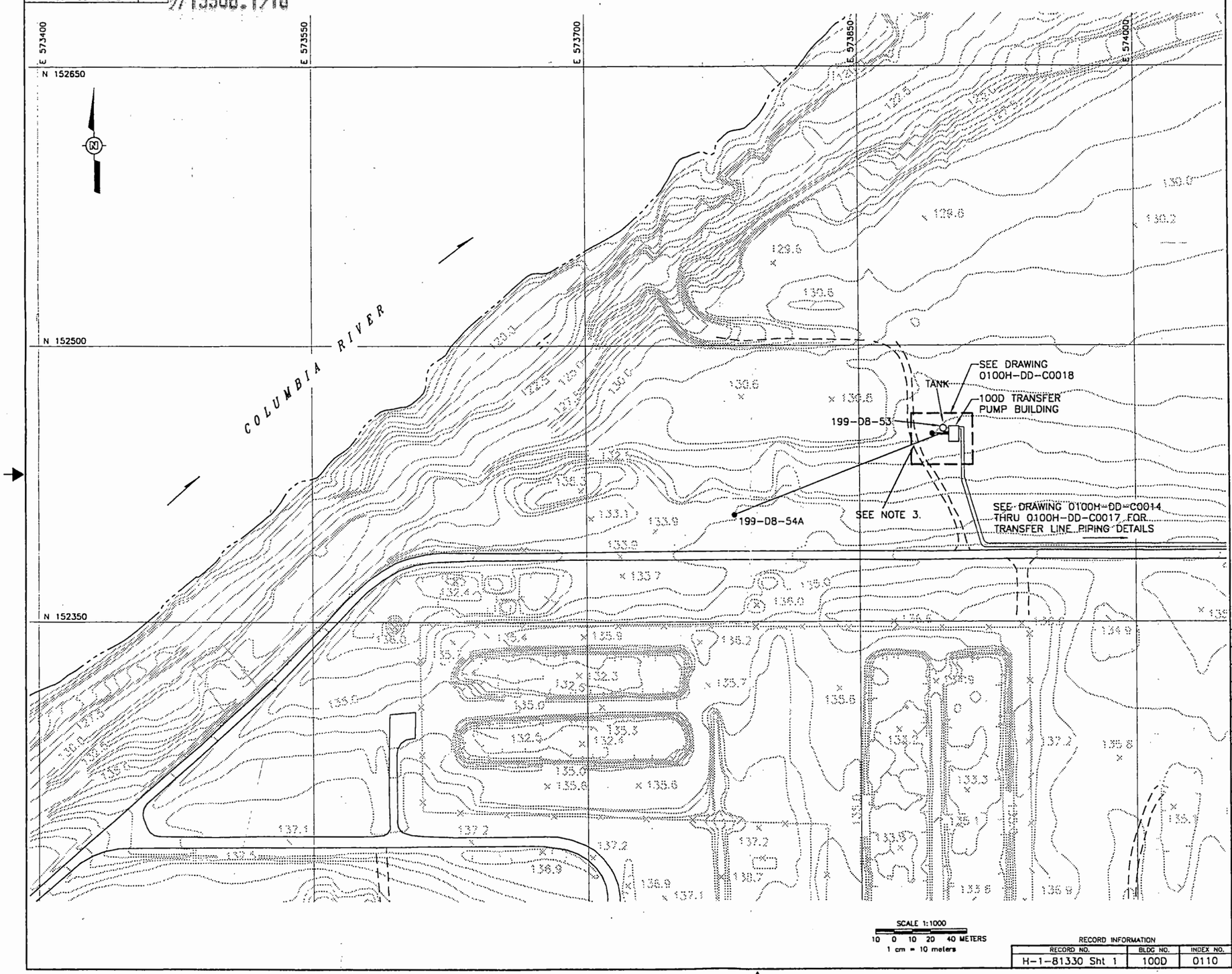
TASK	DRAWING NO.	REV. NO.
100H	0100H-DD-C0013	0

HANFORD

BCH-V7/95

DRAWING NO.	REV. NO.
0100D-DD-C0012	0

9713506.1916



NOTES DOE/RL-96-84 Rev. 0

1. APPROXIMATE PIPE ROUTINGS ARE SHOWN. PIPING ROUTE SHALL BE FIELD LOCATED.
2. ALL PIPE SHALL BE LAID ON GROUND SURFACE.
3. SEE DRAWING 0100H-DD-C0022 FOR TYPICAL PIPE ROAD CROSSING DETAIL.

PRELIMINARY

REFERENCE:

BASE MAP TAKEN FROM 100D AND 100H TOPOGRAPHIC MAPPING, DRAWING NO'S H-13-000127, H-13-000133, H-13-000134, H-13-000141, AND H-13-000142. HORIZONTAL DATUM: NAD-83 LAMBERT PROJECTION. VERTICAL DATUM: NATIONAL GEODETIC SURVEY DATUM, NGVD29, AS PROVIDED BY KAISER ENGINEERS-HANFORD.

JOSEPH A. GAUDIER STATE OF WASHINGTON 15923 PROFESSIONAL ENGINEER

EXPIRES:

REV.	DATE	DESCRIPTION	DRAWN BY	DRAW'T CH'K	ORIG/ ENG'R	ENG'R CH'K	D.C/TCL APPROV	REV ENG'R
0	6/27/96	ISSUED FOR CONSTRUCTION	TLC					

SCALE: AS SHOWN

U.S. DEPARTMENT OF ENERGY
DOE FIELD OFFICE, RICHLAND
HANFORD ENVIRONMENTAL RESTORATION PROGRAM

BECHTEL HANFORD INC. RICHLAND, WASHINGTON | CH2M HILL HANFORD INC. RICHLAND, WASHINGTON

Figure 3-9b. 100-HR-3 100-D Area Conveyance Piping Layout.

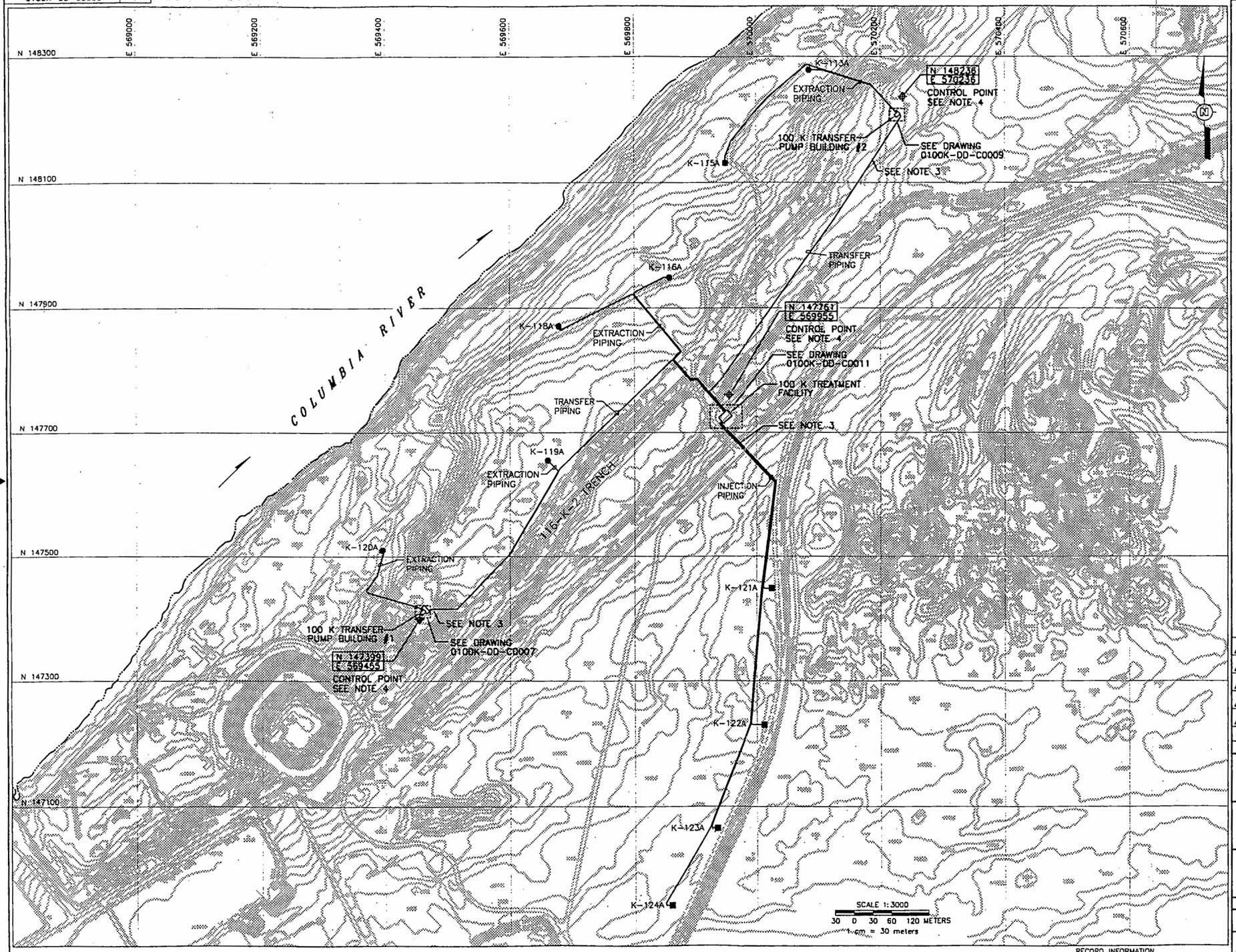
BECHTEL JOB NO.	DOE CONTRACT NO.	CADD FILENAME
22192	DE-AC06-93RL12367	1HDC0012.DWG

RECORD INFORMATION		
RECORD NO.	BLDG NO.	INDEX NO.
H-1-81330 Sht 1	100D	0110

TASK	DRAWING NO.	REV. NO.
100H	0100H-DD-C0012	0

DRAWING NO.	REV. NO.
0100K-DD-C0006	0

9713506.1917



NOTES

DOE/RL-96-84
Rev. 0

1. APPROXIMATE PIPE ROUTINGS ARE SHOWN. PIPING ROUTE SHALL BE FIELD LOCATED.
2. ALL PIPE SHALL BE LAID ON GROUND SURFACE.
3. SEE DRAWING 0100K-DD-C0014 FOR TYPICAL PIPE ROAD CROSSING DETAIL.
4. ALL SURVEY CONTROL POINTS SHALL BE VERIFIED PRIOR TO CONSTRUCTION.

REFERENCE:

BASE MAP TAKEN FROM 100D AND 100H TOPOGRAPHIC MAPPING, DRAWING NO'S H-13-000110, H-13-000111, H-13-000113, H-13-000114, AND H-13-000115. HORIZONTAL DATUM: NAD-83 LAMBERT PROJECTION. VERTICAL DATUM: NATIONAL GEODETIC SURVEY DATUM, NGVD29, AS PROVIDED BY KAISER ENGINEERS-HANFORD.

FIELD TO VERIFY COORDINATES AND ELEVATION PRIOR TO CONSTRUCTION.

PRELIMINARY

ERIC ANDREW NELSON
STATE OF WASHINGTON
32960
PROFESSIONAL ENGINEER

EXPIRES:

REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CK'K	ORIG/ ENG'R	ENG'R CK'K	CL/TEL APPROV	SH PROJ ENG'R
0	6/27/95	ISSUED FOR CONSTRUCTION	TLC					

SCALE: AS SHOWN

U.S. DEPARTMENT OF ENERGY
DOE FIELD OFFICE, RICHLAND
HANFORD ENVIRONMENTAL RESTORATION PROGRAM

BECHTEL HANFORD INC. RICHLAND, WASHINGTON | CH2M HILL HANFORD INC. RICHLAND, WASHINGTON

Figure 3-9c. 100-KR-4 Conveyance Piping Layout.

BECHTEL JOB NO.	DOE CONTRACT NO.	CADD FILENAME
22192	DE-AC06-93RL12367	1KDC0006.DWG

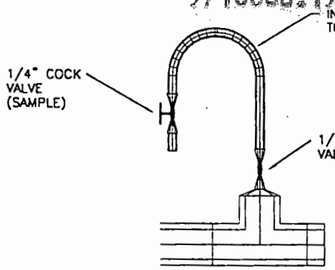
TASK	DRAWING NO.	REV. NO.
100K	0100K-DD-C0006	0

HANFORD

RECORD INFORMATION		
RECORD NO.	BLDG NO.	INDEX NO.
H-1-81686 Sht 1	100K	0110

DRAWING NO.	REV. NO.
0100H-DD-M0006	0

9713506.1918



1 SAMPLE VALVE
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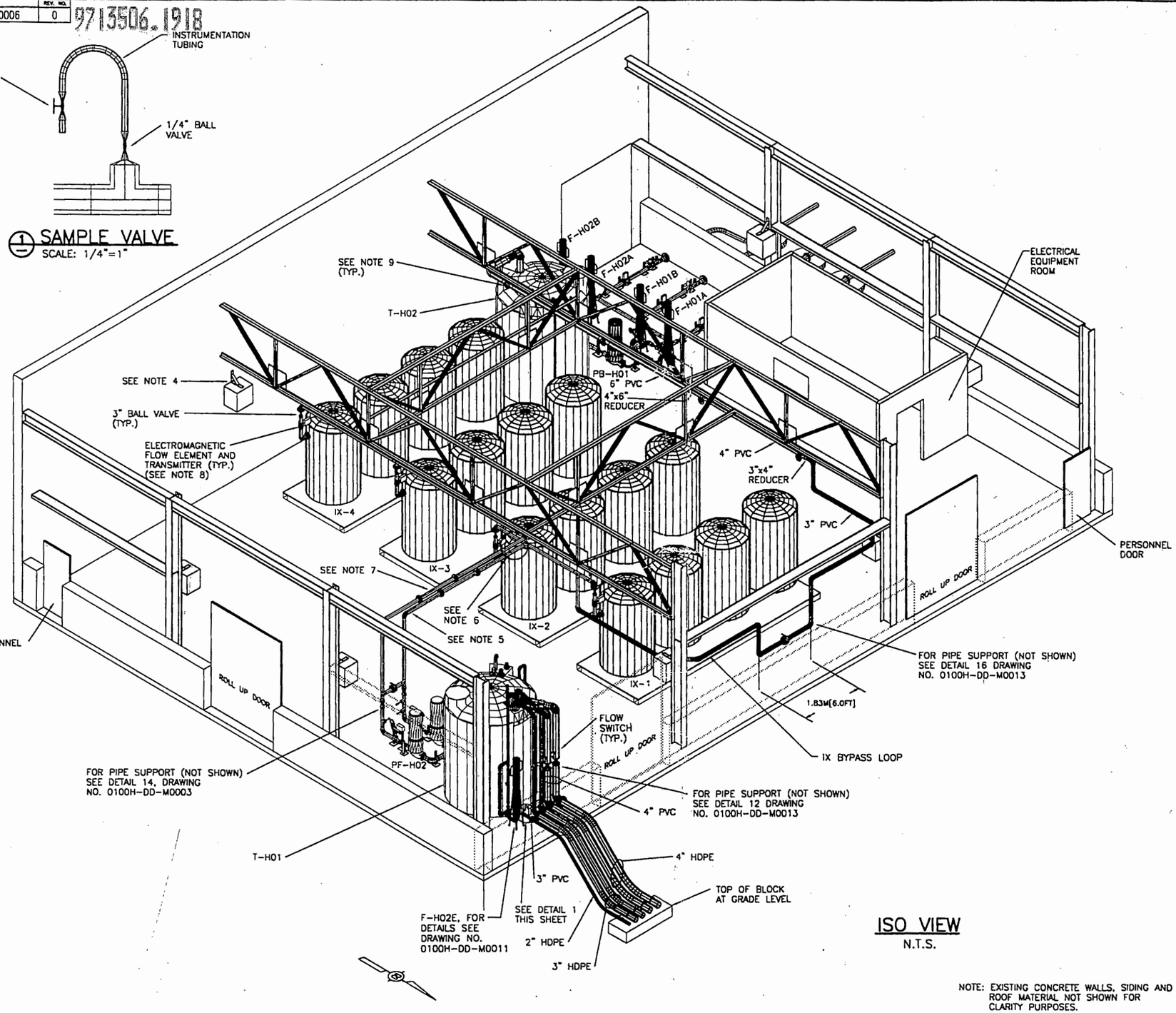

ISO VIEW
N.T.S.

NOTE: EXISTING CONCRETE WALLS, SIDING AND ROOF MATERIAL NOT SHOWN FOR CLARITY PURPOSES.

RECORD INFORMATION

RECORD NO.	BLDG NO.	INDEX NO.
H-1-81051 Sht1	100H	7301

NOTES

DOE/RL-96-84
Rev. 0

1. SEE DRAWING 0100H-DD-M0014 FOR ABBREVIATIONS AND SYMBOLS.
2. REFER TO DRAWING 0100H-DD-M0002 FOR ADDITIONAL SITE DETAILS.
3. OVERHEAD PIPES SHALL BE SUPPORTED FROM BUILDING PURLINS/BEAMS IN ACCORDANCE WITH THE PIPING SPECIFICATIONS.
4. INSTALL WALL MOUNTED HEATERS IN ACCORDANCE WITH MANUFACTURER'S INSTRUCTIONS. THE HEATERS ON THE EAST WALL SHALL BE MOUNTED NOMINALLY 8 FEET FROM THE CONCRETE FLOOR TO THE TOP OF THE HEATER. ALL OTHERS SHALL BE MOUNTED NOMINALLY 10 FEET FROM THE CONCRETE FLOOR TO THE TOP OF THE HEATER.
5. FOR PIPE SUPPORT SEE DETAIL 9 DRAWING NO. 0100H-DD-M0013.
6. FOR PIPE HANGER SEE DETAIL 10 DRAWING NO. 0100H-DD-M0013.
7. PROVIDE 4 FOOT LONG FLANGED SPOOL PIECE (2 PLACES).
8. IX INLET PIPING. MAINTAIN A MINIMUM OF 5 UPSTREAM PIPE DIAMETERS BETWEEN BALL VALVE AND ELECTROMAGNETIC FLOW ELEMENT. PROVIDE A MINIMUM OF 3 PIPE DIAMETERS BETWEEN ELECTROMAGNETIC FLOW ELEMENT AND NEAREST DOWNSTREAM PIPE FITTING. COORDINATE IX INLET PIPING CONNECTIONS WITH IX VENDOR.
9. IX DISCHARGE FLANGE. PROVIDE ADDITIONAL PIPING AND PIPE FITTINGS AS REQUIRED TO CONNECT IX DISCHARGE PORT TO THE FLANGE. COORDINATE IX OUTLET PIPING CONNECTION WITH IX VENDOR.
10. FIELD LOCATE HIGH POINT VENTS.
11. FOR ADDITIONAL DETAILS REFER TO DRAWINGS 0100H-DD-M0005 AND 0100H-DD-M0007.

PRELIMINARY

ERIC ANDREW NELSON, STATE OF WASHINGTON, 32867, REGISTERED PROFESSIONAL ENGINEER

EXPIRES:

REV.	DATE	DESCRIPTION	DRAWN BY	DRAFT CK'R	ORIG/ ENG'R	ENG'R CK'R	G.L/TCL APPROV	ENG MGR/ ENG'R
0	6/17/96	ISSUED FOR CONSTRUCTION	ARK					

SCALE: AS SHOWN

U.S. DEPARTMENT OF ENERGY
DOE FIELD OFFICE, RICHLAND
HANFORD ENVIRONMENTAL RESTORATION PROGRAM

BECHTEL HANFORD INC. RICHLAND, WASHINGTON | CH2M HILL HANFORD, INC. RICHLAND, WASHINGTON

Figure 3-10. 100-HR-3 Groundwater Treatment System.

BECHTEL JOB NO.	DOE CONTRACT NO.	CADD FILENAME
22192	DE-AC06-93RL12367	1HDM0005.DWG

HANFORD	TASK	DRAWING NO.	REV. NO.
	100H	0100H-DD-M0006	0

Table 3-1. Existing Well Performance Test Summary.

Well No.	Saturated Thickness (ft)	Pump Rate (gal/min)	Test Duration (min)	Observed Drawdown (ft)	Predicted Yield (gal/min)	Planned Pump Rate (gal/min)	Cr(VI) Conc. (µg/L)
100-HR-3							
Extraction Wells							
D8-53	8.0	40.0	345.0	<1.0	>50.0	40.0	340.0
D8-54A	10.6	23.0	300.0	4.0	>50.0	40.0	380.0
H3-2A	10.2	265.0	10.0	1.8	>300.0	40.0	110.0
H4-7	NT	NT	NT	NT	NT	NT	NT
H4-11	10.0	44.0	81.0	1.2	50.0	20.0	47.0
H4-12A	10.9	30.0	82.0	5.1	30.0	10.0	NT
H4-15A	12.0	46.0	55.0	2.1	85.0	10.0	NT
Wells Not Selected for Extraction							
H4-4	10.4	10.0	170.0	2.7	11.0	0.0	4.0
H4-10	11.8	235.0	12.0	0.9	>300.0	0.0	11.0
H4-12C	41.0	24.0	131.0	14.3	34.0	0.0	250.0
H4-14	8.0	30.0	56.0	3.0	30.0	0.0	73.0
H4-48	14.4	+50.0	80.0	+4.8	50.0	0.0	NT
100-KR-4							
Extraction Well							
K-20	5.1	30.0	60.0	5.6	--	25.0	100.0
Wells Not Selected for Extraction							
K-18	6.0	8.7	330.0	8.3	--	--	--
K-19	5.1	8.7	300.0	4.1	--	--	--
K-21	6.0	30.0	325.0	6.6	--	--	--
K-22	5.3	3.8	180.0	2.5	--	--	--
K-37	4.7	30.2	60.0	10.3	--	--	--

NT = not tested

Table 3-2. Ion-Exchange Resin Test Summary.

Resin	Dose (g/L)	Test pH	Final pH	Residual Cr (µg/L)	Cr Loading (µg/L)
100-HR-3 Groundwater Ambient pH = 7.7 Cr (µg/L) = 97					
Dowex 21K	20	7.7	7.64	8	380
		5	3.06	6	210
		4	3.12	4	660
SIR-700	20	7.7	3.66	0	580
		5	3.21	0	450
		4	3.29	1	700
Ionac 305	20	7.7	9.39	13.5	100
		5	9.56	8	1,150
		4	9.34	11	700
Lew MP62	20	7.7	8.82	33.5	16
100-KR-4 Groundwater Ambient pH = 8.08 Cr (µg/L) = 124					
Dowex 21K	20	8.04	5.83	2	1,000
		5	3.2	12	540
SIR-700	20	8.04	3.52	1	920
		5	3.28	2	440
Ionac 305	20	8.04	9.94	3	100
		5	9.18	6	200

Table 3-3. Groundwater Treatment System Estimated Startup Conditions.

100 Area	Well No.	Initial Pumping Rate (gal/min)	Average Cr(VI) Concentration (µg/L)	Maximum Cr(VI) Concentration (µg/L)
100-H	H3-2A	40	89	160
	H4-7	20	87	92
	H4-11	10	54	75
	H4-12A	10	78	96
	H4-15A	10	102	121
	D8-53	40	338	368
	D8-54	40	420	480
100-HR-3 GTS	Startup conditions	170	223	265
100-K	K-113A	25	100	N/A
	K-115A	25	125	N/A
	K-116A	25	130	N/A
	K-118A	25	130	N/A
	K-20	25	100	N/A
	K-120A	25	100	N/A
100-KR-4 GTS	Startup conditions	150	114	

NOTES:
1. 100-HR-3 chromium concentration data from Table 2-1 in Appendix B.
2. 100-KR-4 chromium concentration data estimated from chromium distribution maps.

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4.0 INTERIM ACTION IMPLEMENTATION

This chapter describes the planned construction, startup, operation, and maintenance activities for interim action implementation. The schedule of activities is presented in Chapter 6.0 of this document.

4.1 CONSTRUCTION

Sections 4.1.1 through 4.1.6 describe construction aspects of interim action implementation. Construction activities will be performed according to the schedule presented in Chapter 6.0 of this document. A more detailed schedule that will control construction activities will be developed as the project progresses. The construction schedule will be updated on a weekly basis and will become part of the project files after completion of construction activities.

4.1.1 Well Drilling

To implement the interim action, the following nine new wells will be constructed at the 100-HR-3 Operable Unit:

- Three compliance monitoring wells in 100-D Area
- One performance monitoring well in 100-D Area
- Two compliance monitoring wells in 100-H Area
- Three injection wells in 100-H Area.

At the 100-KR-4 Operable Unit, the following 13 new wells will be constructed to implement the interim action:

- Three compliance monitoring wells
- Six extraction wells
- Four injection wells.

Well construction is being controlled through the *100-HR-3 and 100-KR-4 Pump-and-Treat Description of Work* (BHI 1996b). A schematic diagram of a typical well is provided in Figure 4-1. In addition, a cultural resources protection plan has been developed to help control drilling activities in the 100-KR-4 Operable Unit, a cultural resource sensitive area. This plan will address protection of cultural resources in the 100-KR-4 Operable Unit during the drilling, construction, and operations phases of the interim action. Drill cuttings and other waste from drilling activities will be controlled in accordance with waste management plans. Appendix D provides additional information concerning waste management during the interim action.

New injection, extraction, and compliance wells will be tested prior to connection to the transfer piping to confirm the well's potential. It is anticipated that these wells will be pumped for up to

8 hours per well during well development. In addition to extraction tests, injection wells will be tested by injecting potable water at rates high enough to confirm the well's potential as an injection well.

Well drilling is scheduled to begin in June 1996 and to be completed in September 1996. The schedule supports balance-of-plant construction to allow full interim action implementation to begin by July 1997 for 100-HR-3 and by October 1997 for 100-KR-4.

4.1.2 Balance of Plant

In general, the balance of plant includes all system components from the extraction well pumps through the injection well pipes. The major balance-of-plant components include the following:

- Extraction well pumps
- Extraction well head assemblies and control equipment
- Piping from well heads to the transfer pump buildings
- Transfer pump buildings
- Piping from the transfer pump buildings to the influent storage tank
- Influent storage tank, feed pumps, and piping to the ion-exchange unit
- Piping from the ion-exchange unit, feed pump, and effluent storage tank
- Piping from the effluent storage tank to the injection well head assemblies
- Injection well head assemblies
- Injection well pipes
- Power supplies for equipment and instrumentation
- Instrumentation
- Control system.

Balance-of plant-construction will follow the schedule presented in Chapter 6.0 of this document.

4.1.3 Groundwater Treatment System

Construction of the ion-exchange units will occur at the vendor's facility. The ion-exchange units will be delivered to the treatment facilities as completed products. The ion-exchange units will be equipped with appropriate flanges and electrical and control connections to allow connection to the balance of plant described in Section 4.1.2.

Construction of the ion-exchange units will be controlled through a procurement contract to be issued to the ion-exchange unit manufacturer. The procurement contract will include a schedule for delivery of the ion-exchange units that will support the overall construction schedule for the 100-HR-3 and 100-KR-4 Operable Units.

4.1.4 Restoration of Disturbed Areas

Disturbance to natural vegetation and habitat will be minimized by using existing roads and drill sites where practicable. Where disturbance is unavoidable, as where water transfer lines must cross a previously undisturbed area, cultural resources and ecological reviews will be conducted to identify controls to limit disturbances. Where disturbances do occur, restoration will be performed according to a mitigation action plan. Areas of disturbance include the following:

- Drill pads and access roads for well sites
- Transfer pump building locations
- Water transfer lines
- Power pole installations
- 100-KR-4 treatment facility building.

Construction of drill pads and, in some locations, access roads will be necessary to allow access of drilling equipment. Because occasional maintenance of the wells and well pumps is likely over the course of the interim action, these disturbed areas will not be restored following interim action construction. Following completion of the interim action, an assessment will be made to determine whether the wells at these locations will continue to be needed. If so, restoration of drill pads and roads may be deferred until the wells are no longer needed.

At the completion of the interim action, the need for the transfer pump buildings and 100-KR-4 treatment facility building will be evaluated. An evaluation of potential source remediation activities in the area will be made. If the buildings are needed by another project, they will be transferred to the other project. If the buildings are not needed, and the area will not be disturbed again by source remediation activities; the buildings will be demolished, and the building sites restored according to the mitigation action plan. If, in the future, the area will be disturbed again by source remediation activities, restoration of the area will be postponed until the source remediation activities have been completed.

Groundwater conveyance pipe will be installed in a manner that minimizes disturbance to existing vegetation. It is anticipated that conveyance pipe and associated conduit will be laid over existing vegetation, where practicable, to limit trenching. Following completion of the interim action, conveyance pipe will be removed, if not needed for other activities, and the disturbed areas restored according to the mitigation action plan. If planned source remediation activities will disturb the area at a later time, restoration of the disturbed areas may be postponed until the source remediation activities have been completed.

Power poles will be installed in both operable units to supply power for well pumps and transfer pump buildings. Overhead power is less costly than on-ground conduit and will help limit disturbance to cultural and ecological resources. Following completion of the interim action, an assessment will be made to determine if the power poles will be needed. If so, restoration of power pole sites may be deferred until the power poles are no longer needed. If the power poles are not needed, the disturbed areas will be restored according to the mitigation action plan.

4.1.5 Construction Health and Safety

A site-specific health and safety plan will be prepared and implemented for well drilling and construction activities. The health and safety plan will address the health and safety considerations for construction, construction oversight personnel, and visitors. Every subcontractor performing work associated with the interim action will be required to prepare and submit a subcontractor health and safety plan. Subcontractor health and safety plans will be reviewed for compliance with Hanford Site requirements and approved by ERC representatives before the subcontractor begins work.

4.2 READINESS EVALUATION

A readiness evaluation plan will be developed in fiscal year (FY) 1997. The plan will identify activities and documents (collectively referred to as "readiness evaluation items") that will be completed to support system operations. Readiness evaluation items will be identified as either "pre-startup" or "post-startup." Pre-startup items must be completed before startup of the system. Post-startup items can be completed after startup. The plan will identify persons responsible for various readiness evaluation items and will include, as attachments, a schedule and checklist for the readiness evaluation. The readiness evaluation will be conducted per Engineering Department Project Instruction (EDPI) 432-01, "Readiness Evaluation" (BHI-DE-01).

4.3 STARTUP PROCEDURES

A startup procedure will be developed prior to startup. The startup procedure will address acceptance testing, calibration of instruments, testing of system components, and testing and startup of the overall system. The startup process ensures that the system will meet design requirements, operate safely, and results in a fully functioning treatment system.

It is anticipated that startup of the extraction system will involve a phased approach. One extraction well will be started and additional wells started in 1- to 3-day increments until all extraction wells in a given area are operational. This ramping-up period will allow the wells and transfer piping to be observed and trouble-shooting to be performed as needed.

If a problem is found in one treatment system during startup activities, an evaluation will be conducted to determine if the problem is a concern for the other system as well. If only one system is impacted by a problem identified during startup, startup activities at the other system will continue toward full operation.

4.4 OPERATION AND MAINTENANCE

The following subsections describe the operation and maintenance of the extraction well system, the treatment system, and the injection well system.

4.4.1 Controlling Documents

System operations will be controlled through the use of operations and maintenance manuals. Operations and maintenance manuals will provide operating and maintenance procedures, as well as specify maintenance and calibration schedules. Operations and maintenance manuals will be prepared prior to the start of operations.

A health and safety plan will be prepared prior to operations. The health and safety plan will identify requirements for the safe operation of the treatment system.

An operations waste management plan will be developed to manage waste produced during system operations. The waste management plan will specify waste characterization requirements for various waste types, waste storage requirements, and waste disposal requirements. This waste management plan will be finalized before the start of operations.

As noted in Section 3.1.3, a performance monitoring plan will be developed to identify and integrate interim action monitoring activities. This performance monitoring plan will identify operational monitoring requirements applicable to system operations. The performance monitoring plan will be developed prior to system operations and will require regulatory approval.

4.4.2 Extraction Well System Operations and Maintenance

Operation of the extraction well system will be on a continuous basis during the initial phases of the interim action. A revised pumping scheme (e.g., intermittent pumping) may be implemented at a later time. The system has been designed to run on an essentially continuous basis.

Extraction wells may be shut down occasionally so that maintenance activities can be performed. Maintenance activities will be limited and are likely to include possible well redevelopment activities and pump maintenance. The efficiency of the extraction wells may change over time because well screens or filter packs may plug, especially where existing wells that were not so designed will serve as extraction wells. If plugging occurs, occasional maintenance to clear the well screens and filter packs may be necessary. Well pumps may occasionally fail and require replacement. Downtime for maintenance will be kept to the minimum required.

Although unlikely, extraction wells may occasionally be shut down during extremely cold weather. In the event of a shutdown, transfer lines from the extraction wells to the transfer pump buildings are designed to drain back to the extraction wells by gravity drainage. Drainage of the water transfer lines between the transfer pump buildings and the GTS will not be possible due to

their length. In the event that flow is stopped for an extended period of time during cold weather, undrained water in the water transfer lines may freeze. This may render the transfer lines unusable until thawed and would necessitate shutdown of the extraction wells. However, the water transfer lines are designed to freeze and thaw without damage to the lines. In addition, the D to H transfer line consists of two separate water lines. In the event that one line freezes, the other line, if available, is designed so that it can continue to operate.

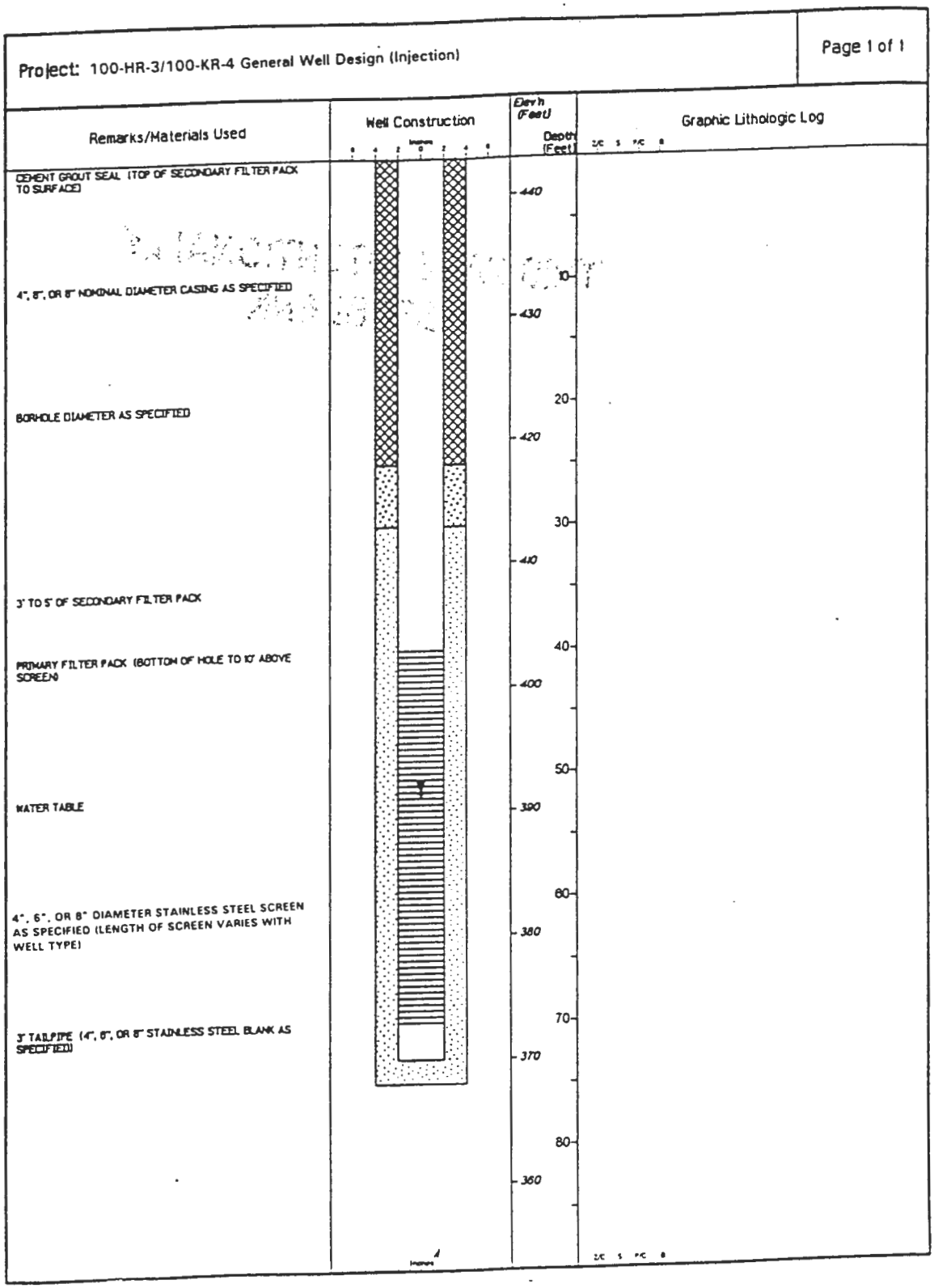
4.4.3 Treatment System Operations and Maintenance

Operation of the treatment system will be essentially continuous or will be of durations necessary to process water from the continuous operation of the extraction well network. Operation of the treatment system will be controlled by an operating procedure that will be developed as the system design progresses. The operating procedure will be finalized before the start of full-scale operations and will include preventive maintenance and instrument calibration requirements.

4.4.4 Injection Well System Operations and Maintenance

The injection well systems will operate in conjunction with the treatment system to inject treated groundwater. The injection well system will use new wells designed specifically as injection wells. This should limit the amount of well maintenance required. In addition, backup wells will be available in both operable units to allow continued injection in the event of a well problem. As the interim action progresses, the efficiency of the injection wells may decrease due to air entrainment, bio-fouling, well screen encrustation, or other effects. Measures will be taken to mitigate, as practicable, the loss of injection well efficiency. If injection well efficiency decreases significantly, maintenance activities will be performed, as practicable, to address the problem.

Figure 4-1. General Well Completion Diagram.



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5.0 INTERIM ACTION MONITORING PROGRAM

This chapter discusses the approach for monitoring the performance of the 100-HR-3 and 100-KR-4 interim actions and the methods to be used for assessing their effectiveness. The interim action monitoring program will include the following distinct monitoring elements.

- **Compliance Monitoring.** The objectives for compliance monitoring are to perform the appropriate sampling, analysis, and data evaluation necessary to meet the requirements of the interim action ROD.

- **Performance Monitoring.** The objectives for performance monitoring are to obtain water level and water quality data necessary to optimize performance of the groundwater extraction system, document aquifer and chromium plume response to pumping and injection, and obtain supplemental data to support final remedy selection.

- **Operations Monitoring.** The objectives for operations monitoring are to conduct the appropriate level of sampling, analysis, and equipment inspection necessary to ensure safe operation and function of the groundwater extraction, injection, and treatment systems.

The compliance monitoring activities described in this chapter are designed to meet the requirements of the interim action ROD. Sampling and analysis procedures for implementing compliance monitoring, in addition to activities required to support the performance and operations monitoring programs, will be presented in the 100-HR-3 and 100-KR-4 interim action performance monitoring plan to be prepared during the implementation phase.

5.1 REMEDIAL ACTION OBJECTIVE MONITORING APPROACH

This section describes how the 100-HR-3 and 100-KR-4 interim actions will be monitored to demonstrate their effectiveness and how the monitoring data will be evaluated to show that the remedial action objectives are being met, or adequate progress is being achieved.

The interim action ROD describes three remedial action objectives for the 100-HR-3 and 100-KR-4 interim action. These remedial action objectives can be stated as follows to allow measurement of success:

- Protect aquatic receptors from chromium-contaminated groundwater discharging to the Columbia River at concentrations above 11 μg/L

- Protect human health from exposure to groundwater containing chromium and other co-contaminants exceeding EPA/Ecology maximum contaminant levels

- Provide information to select a final remedy.

The 100-HR-3 and 100-KR-4 interim actions were designed to intercept chromium migrating towards the river, especially in near-river areas where elevated chromium concentrations have been detected in monitoring wells, or river substrate samples.

5.1.1 Protection of Aquatic Receptors

Protection of aquatic receptors is the primary remedial action objective requiring a high level of data quality and technical consideration. Because it is impractical to routinely monitor chromium concentrations at aquatic receptor exposure points, onshore monitoring of groundwater near the river and data evaluation will be used to assess the effectiveness of the interim action at achieving this objective. Protection of aquatic receptors will be demonstrated by evaluating interim action monitoring data to show the following:

- **Decrease the concentration of chromium in groundwater discharged to the river.** Chromium concentrations will be regularly monitored at locations between the extraction wells and the river, or as near the river as practicable. A declining concentration trend, calculated using a four-sampling-event running average, will be a positive indication of interim action effectiveness.

- **Establish hydraulic gradient control.** Groundwater elevations will be measured in selected wells adjacent to and inland from the river. A decreased hydraulic gradient between the aquifer and the river, or groundwater flow from the river toward the extraction wells, will be a positive indication of interim action effectiveness.

5.1.2 Protection of Human Health

The primary pathway for exposure to groundwater containing chromium and other co-contaminants are seeps along the riverbank. Control of this pathway will be achieved by implementing the following actions for the duration of the interim action, or until such time that the pathway is eliminated or contaminant concentrations decline below health-based levels:

- Maintain institutional controls that prevent access to areas where groundwater containing contaminants above health-based levels occurs

- Maintain signs along the river shoreline within the operable unit boundaries indicating a restricted access area

- Modify, if necessary, the existing groundwater use notification to identify areas in 100-HR-3 and 100-KR-4 where chromium and co-contaminant concentrations exceed protective levels. The notification would consist of maps and narrative descriptions of areas where groundwater use is restricted.

Institutional controls will be inspected on a semi-annual basis and the results documented in the facility operating record.

5.1.3 Provide Information for Final Remedy

Monitoring of the interim action will generate data that can be used in assessing the cost and technical feasibility of pump and treat to decrease contaminant concentrations to levels protective of human health and the environment. During system operations, information will be developed on treatment cost, system efficiency, hydraulic impacts, and contaminant removal effectiveness. The following subsections describe the approach that will be used for calculating these parameters.

5.1.3.1 Treatment Cost. The cost of treatment will be determined on a dollar per liter of groundwater extracted. The cost will be determined using the interim action capital (amortized over an assumed 10-year design lifetime) plus annual operations and maintenance costs, divided by the annual volume of groundwater extracted for each operable unit.

5.1.3.2 System Efficiency. System efficiency will be based collectively on chromium removal efficiency and system operating efficiency. Chromium removal efficiency will be determined based on the percentage of chromium removed by the treatment system. System operating efficiency will be determined from the percentage of time the GTS operates divided by the total time available for operation.

5.1.3.3 Hydraulic Impacts. The hydraulic impacts of the pump-and-treat technology will be assessed by estimating the extent of chromium plume capture that can be achieved for various pumping strategies. This determination will include estimates of hydraulic impacts in the vicinity of the river where variable river stage is expected to have a pronounced effect on plume capture.

5.1.3.4 Effectiveness of Contaminant Removal. The effectiveness of chromium removal will be determined using the results of concentration monitoring performed after the interim action is terminated. Co-contaminants will not be included in this evaluation because no significant removal by the GTS is required.

5.2 APPROACH FOR MONITORING SYSTEM DESIGN REQUIREMENTS

In addition to collecting data necessary to satisfy the remedial action objectives, the interim action ROD contains specific requirements for the design of the interim action monitoring network. These requirements include the following.

- Monitoring shall be performed at sufficient locations above the common high river mark to evaluate the performance of the remedial action.

- A network of piezometers (or comparable techniques) will be installed and monitored such that the capture zone around the extraction wells can be estimated.
- Baseline sampling will be conducted prior to start of the interim action.
- Chromium compliance monitoring will be conducted at multiple depth intervals.
- Groundwater sampling will be conducted when dilution by river water at the compliance points is minimal.
- On an infrequent basis, co-contaminants will be monitored to support ongoing activities associated with selecting a final remedy.

The interim action monitoring program includes two monitoring well types: compliance wells and performance wells. Compliance monitoring wells are designed for obtaining water level and water quality data at locations as near the river as practicable. Data collected from the compliance monitoring wells will be used to assess the effectiveness of the interim action at protecting aquatic receptors. Performance monitoring wells are designed for water level and less frequent water quality measurements at inland areas and will provide independent verification of interim action effectiveness at reducing chromium flux towards the river.

5.2.1 Monitor Well Construction and Location

Monitoring wells constructed similar to the extraction wells and in accordance with WAC 173-160 standards are the preferred method for monitoring interim action performance. However, where acceptable existing wells are available, new wells will not be installed. Use of wells versus drive points ensures the collection of data that are comparable between locations reducing potential data anomalies resulting from differences in well screen lengths. New monitoring wells will be constructed so that the well screen is open to a significant portion of the saturated thickness of the aquifer to provide improved monitoring flexibility and promote cost effectiveness. Drive points may be installed at a future date to provide a mechanism for obtaining timely information in areas where conflicting results are obtained or monitoring well coverage is determined to be inadequate.

The location and number of monitoring wells were determined from existing well spacing intervals in each of the three areas and numerical modeling information (Figures 5-1, 5-2, and 5-3). Compliance monitoring wells were generally placed at locations midway between the extraction wells and the river or, in the case of the 100-H Area, as near the river as practicable.

5.2.2 Monitoring Parameters

Interim action performance will be based on its ability to establish positive hydraulic gradient control and initiate timely chromium concentration declines at the compliance monitoring well locations. Proposed monitoring parameters include water level measurements, field hexavalent

chromium measurements, co-contaminants identified in the interim action ROD, and specific conductance.

Water level measurements will be performed using dedicated pressure transducers. Water level data from the extraction and injection well locations are available on a continuous basis through the OIC. Water level data from the compliance and performance monitoring wells will either be manually downloaded or telemetered to a central location.

Hexavalent chromium concentrations will be measured in the field using a modified version of the Hach™ Method. The ERC has successfully developed a three-point calibration procedure that provides a detection limit of 5 µg/L. Initially, quality assurance will be provided through 10% field duplicate and spike samples and 10% sample splits with an EPA/Ecology-certified laboratory. Upon satisfactory review of the results by the regulatory agencies, these requirements may be reduced to 5% field duplicates and spikes and 5% laboratory splits, or less as agreed to by the Tri-Parties. If subsequent data evaluations indicate that a 5% quality assurance sample frequency is inadequate, the quality assurance sample frequency may be increased to 10% if requested by DOE or the regulatory agencies. Water quality samples for laboratory chromium analysis will be tested using EPA Method SW7421, which has a detection limit of 2 µg/L.

Monitoring for co-contaminants will be performed over the course of the interim action to obtain information for final remedy selection. Because the interim action is not designed to remove co-contaminants, monitoring will be limited to extraction well locations and the GTS influent and effluent. The co-contaminant list for 100-HR-3 includes nitrate, strontium-90, tritium, uranium, and technetium-99; and for 100-KR-4, tritium and strontium-90.

Analysis for co-contaminants will be performed using EPA-approved methods by a certified laboratory. Quality assurance will include 10% field duplicate samples and one matrix spike/matrix spike duplicate per sample batch. Given the intended data use, laboratory splits are not necessary.

The groundwater extraction system has been designed to minimize infiltration from the river. However, river stage and hydrogeologic conditions varying from those used for the numerical modeling may result in more or less river water infiltration. The actual timeframe for sampling to occur in order to minimize river water dilution will be determined using specific conductance, river stage, and compliance monitoring well water level data developed from prestartup and startup monitoring information. To confirm that analysis results from the compliance wells have not been significantly biased by the presence of river water, field measurements of specific conductance will be performed during each sampling event.

5.2.3 Sampling Frequency

Prior to system startup, an initial chromium concentration level will be established for each compliance monitoring well location. This initial concentration will be determined from the

average of three to four samples collected over the 8- to 12-month period preceding startup. An average concentration approach reduces the impact of temporal fluctuations, which could result in a biased high or low initial concentration.

The groundwater extraction and injection wells will be sampled for chromium and co-contaminants following installation and development. A second round of confirmation sampling may be performed prior to startup if construction activities permit.

During the first 3 months of operation (startup period), the compliance monitoring wells and extraction wells will be tested monthly for chromium to provide timely information on initial interim action performance. At the end of the 3-month startup period, the sampling frequency will be reduced to a quarterly basis until such time that an alternate frequency is warranted.

Sampling for co-contaminants will be performed semiannually at each of the extraction well locations and from the GTS influent and effluent. This frequency will be maintained until an alternate frequency is determined. Sampling locations, parameters, and their frequency are shown in Table 5-1.

5.2.4 Vertical Sampling

During the prestartup period, compliance wells in the 100-D and 100-K Areas will be sampled at multiple depths to assess the vertical distribution of chromium in the aquifer. Samples will be collected using an inflatable packer, or equivalent device, to isolate discrete intervals from which the sample will be withdrawn. In the 100-D Area, samples will be collected from the top and base of the aquifer. In the 100-K Area, samples will be collected at 1.5-m (5-ft) intervals spanning the aquifer thickness to document chromium concentrations at all depths prior to remediation. The sampling will be conducted concurrently with the prestartup baseline sampling. Test results will be used to assess the integrity of the sampling method and to determine if vertical sampling should be incorporated into the interim action monitoring program.

Vertical sampling in the 100-H Area using the above approach is limited by the relatively thin aquifer thickness throughout the plume area (~3 to 5.4 m [10 to 17 ft]). To obtain information on the vertical distribution of chromium once the interim action is under way, sampling of well clusters H4-12B, H4-12-C and H4-15B, H4-15-C will be performed.

5.2.5 Coordination With Other Monitoring Programs

To avoid duplicative sampling efforts and promote data exchange with other ongoing groundwater monitoring programs, coordination will occur during the data quality objectives process for the performance monitoring plan.

5.3 TREATMENT SYSTEM PERFORMANCE CRITERIA APPROACH

The interim action ROD requires that the GTS meet the following performance requirements.

- The GTS will reduce effluent chromium concentrations to the maximum extent practicable. However, groundwater above 50 µg/L chromium will not be discharged.
- The extraction and treatment system shall be designed (and operated) to run on an essentially continuous basis.
- The pump-and-treat interim action will continue until selection of the final action, or until termination is demonstrated to be appropriate.

5.3.1 Monitoring for Treatment System Removal Efficiency and Injection Discharge

The interim action ROD requires chromium to be removed to the maximum extent practicable with chromium concentrations not to exceed 50 µg/L in the GTS discharge. This requirement will be met through analysis of GTS influent and effluent samples. The samples will be taken from collection points (Figure 5-4) located adjacent to the inline chromium monitors. Once the accuracy and precision of the chromium monitor is established, no further manual testing will be performed except for periodic confirmation samples. Conversion to the inline monitor for influent and effluent testing is expected to occur by the end of the 3-month startup period.

During the startup period, GTS effluent sampling and analysis will be conducted weekly. The weekly data will be used for comparison with the 50-µg/L discharge limit and a treatment level to be developed during the startup and operation periods. The treatment level will represent a balance between the level that is technically feasible, is cost effective, and optimizes resin use. Chromium removal efficiency will be determined from the difference between the weekly influent and effluent concentrations.

Analysis of samples collected from the GTS will be performed using the modified Hach™ Method. Field analyses represent the most effective method for obtaining timely information on GTS operation. Laboratory confirmation of field analysis results will be performed on a graduated frequency basis. During startup, this frequency may occur weekly, increasing to a monthly interval and quarterly thereafter as confidence in system performance improves. Additional information on the sampling approach will be presented in the performance monitoring plan.

5.3.2 Monitoring for System Operation Efficiency

The groundwater extraction and treatment systems have been designed to operate on an essentially continuous basis. The design allows various system components to be isolated for maintenance and repair, thereby allowing other system components to continue operating. The

design also contains several contingency provisions, such as an extra injection well and modular treatment design, that enable the system to continue running, although at a potentially reduced rate, in the event of major system failures.

5.3.3 Testing for Spent Resin Characterization

Data obtained from operation of the 100-HR-3 pilot-scale pump-and-treat system indicates that spent resin (Dowex 21K) does not exceed levels for designation as a TCLP-chromium dangerous waste. Chromium concentrations from the 100-HR-3 and 100-KR-4 interim action are expected to be significantly less. Therefore, TCLP-chromium levels for spent resin generated from 100-HR-3 and 100-KR-4 should also be less than the 1.92 mg/L detected for spent resin generated from the 100-HR-3 pilot system.

Spent resin testing requirements will be based on ERDF waste acceptance requirements performed at an appropriate frequency to demonstrate compliance with the criteria. It is expected that an initial waste characterization test for TCLP-chromium, free liquid content, and co-contaminants will be necessary. Thereafter, no new additional characterization testing would be performed unless (1) a significant change in the characteristics of the groundwater being treated is identified based on evaluations of semiannual influent co-contaminant monitoring, (2) a change in the treatment process occurs, or (3) a different resin is used.

5.4 INTERIM ACTION TERMINATION

The interim action ROD provides three criteria for termination of the interim action: (1) successful completion of the interim action is demonstrated, (2) the interim action is no longer effective, or (3) a final remedy is selected. Proposed criteria for termination under these criteria are described below.

5.4.1 Successful Completion of the Interim Action

Successful completion of the interim action will be based on its ability to remove chromium to a level that provides long-term protection of aquatic receptors in the river. This success will be measured by water quality samples collected from both the extraction and compliance monitoring wells. Pumping of the extraction wells will continue as long as chromium concentrations remain above 22 µg/L and the rate of progress towards this level is reasonable and cost effective. Once water quality samples from both the extraction wells and compliance wells have remained below 22 µg/L for a full 1-year period, a phased shutdown of the extraction system will be implemented. Extraction wells will be shut down at quarterly intervals beginning with perimeter wells and concluding with interior wells. During the phased shutdown period, water quality samples collected from idled extraction wells and downgradient compliance wells will provide an early indication as to whether chromium concentrations will remain below 22 µg/L.

Once all of the extraction wells are shut down, the compliance wells will be sampled on a quarterly basis for 1 year and the data used to calculate an upper-confidence interval using the methodology described in WAC-173-340-720 (8e). If, at the end of the 1-year monitoring period, the upper-confidence interval is less than the protective level, a request for interim action termination would be submitted. If, at any time during the 1-year compliance monitoring period, the data indicate a confirmed increase above the protective level, a proposal for restarting the interim action would be prepared.

At this time, 22 µg/L is the protective level for terminating the interim action. If during the course of the interim action it is determined that an alternate concentration, based on improved dilution ratio estimates, is warranted, a request to modify the dilution ratio and corresponding 22-µg/L protective level may be submitted by any of the Tri-Parties for review and acceptance by the others prior to implementation.

5.4.2 Interim Action No Longer Cost Effective

If the cost of chromium removal from the aquifer increases disproportionately to the environmental benefit received, the interim action may no longer be cost effective. Additionally, if new technologies are developed that provide equivalent or greater environmental protection at a lower cost, the current interim action may no longer be cost effective. Any cost-effective determination would be studied carefully and regulatory agency concurrence obtained before implementation.

5.4.3 Selection of a Final Remedy

Selection of the final remedy includes evaluation of cumulative risks associated with residual contamination resulting from cleanup of the contaminant plume(s) or failure to reach cleanup goals because cleanup was determined to be technically impracticable. Prior to selecting a final remedy, a cumulative risk assessment will be performed to assess human health and environmental exposures that result from all remaining contaminants. A finding that unacceptable risk levels still remain would require that additional cleanup alternatives be evaluated and a final feasibility study report prepared. The final feasibility study report would form the basis for a final proposed plan and ROD.

A finding that acceptable levels of risk are present at the conclusion of the interim action would not require preparation of a final feasibility study, and the interim action proposed plan and ROD would be the primary decision documents.

5.5 REPORTING OF INTERIM ACTION MONITORING DATA

Regular evaluation and reporting of monitoring data will be necessary to document interim action performance, identify conditions potentially impacting system performance, and determine if the interim action needs to be modified.

Abbreviated monthly summaries will be used to communicate general information to project management staff and regulatory agency personnel. A typical data summary would provide monthly and cumulative information on number of operation days, liters of groundwater and kilograms of chromium removed, the average and maximum influent and effluent chromium concentrations, kilograms of resin used, and water level trends in injection well(s).

Quarterly monitoring reports, presented in a memorandum format, will be used to present the results from quarterly sampling activities. These reports would include tabular summaries and graphical depictions of compliance and extraction well analysis results and trends, semiannual co-contaminant analysis data, graphical depictions of groundwater elevation trends and flow patterns, and a quality assurance summary. A brief narrative summary would also be included with recommendations for modifying operation if warranted.

Less-frequent performance evaluation reports represent an important vehicle for conducting comprehensive evaluations of system operations data. The performance evaluations will integrate data collected from other ongoing 100-HR-3 and 100-KR-4 programs and will be conducted at the conclusion of 6 months, 18 months, 30 months, 42 months, and 66 months of interim action operation. Performance evaluation results will be used to make recommendations on modifications to the target areas, alternate pumping strategies, treatment system modifications, or alternate sampling parameters and frequencies.

Figure 5-1. Interim Action Monitoring Well Locations, 100-HR-3 Operable Unit, 100-H Area.

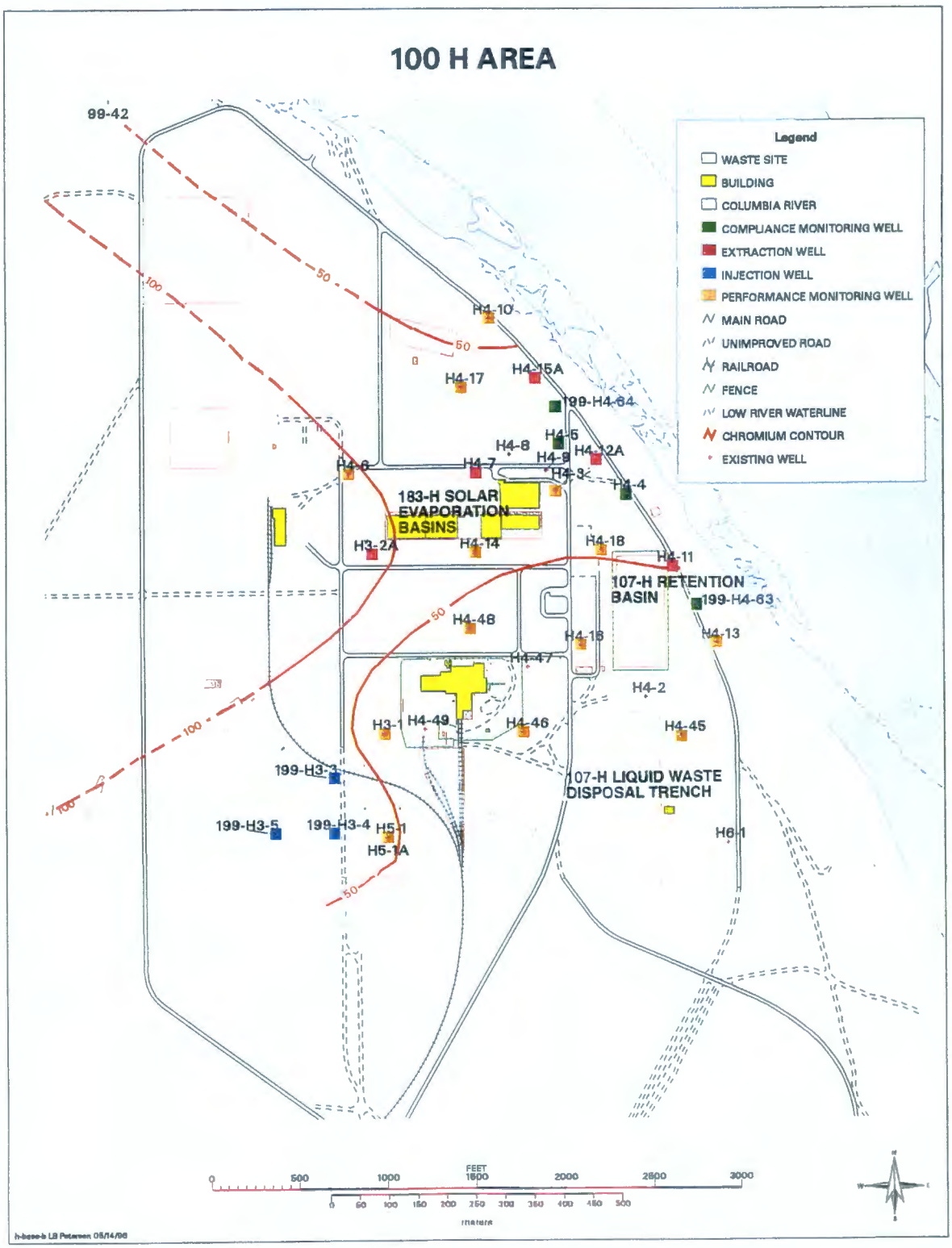


Figure 5-2. Interim Action Monitoring Well Locations, 100-HR-3 Operable Unit, 100-D Area.

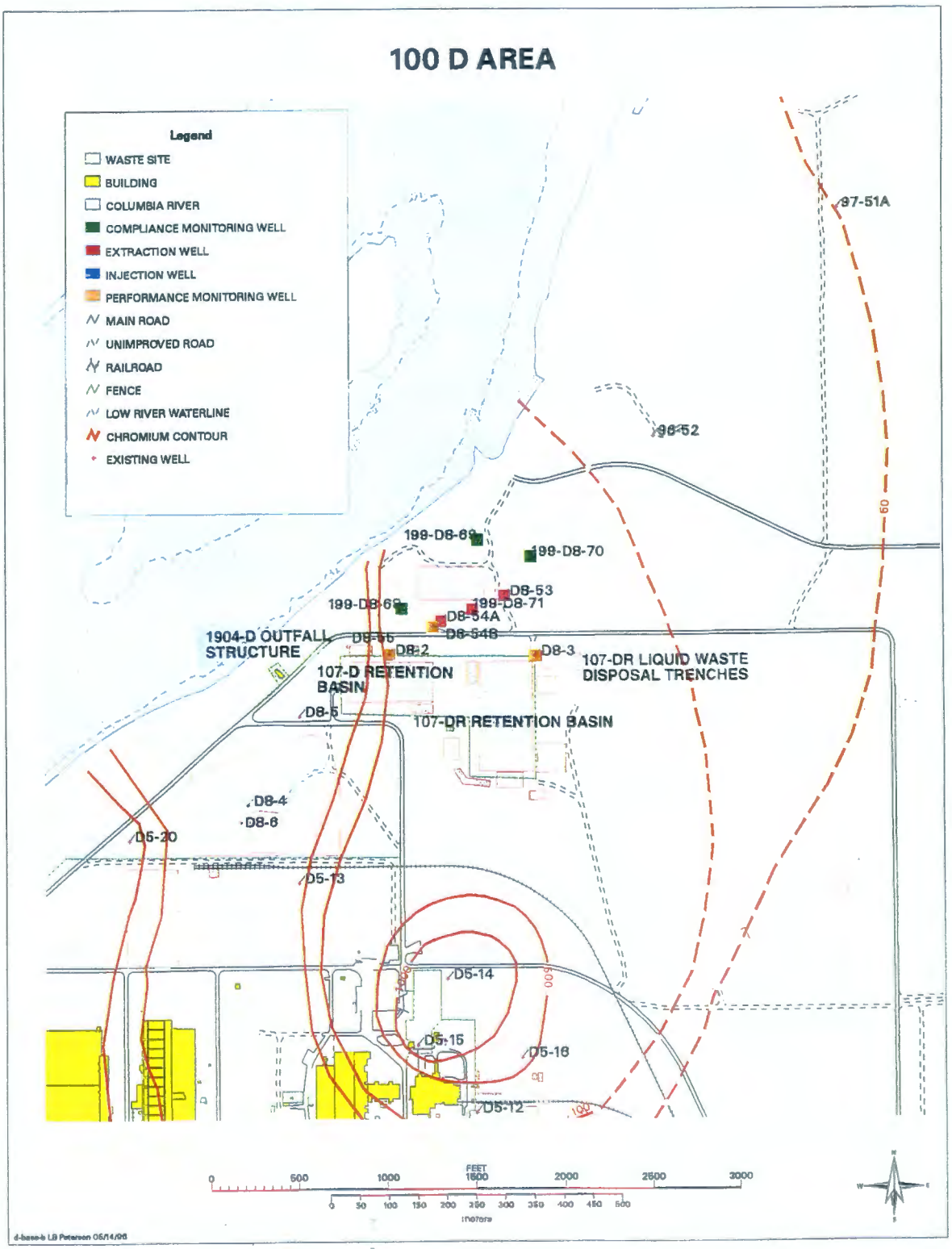


Figure 5-3. Interim Action Monitoring Well Locations, 100-KR-4 Operable Unit.

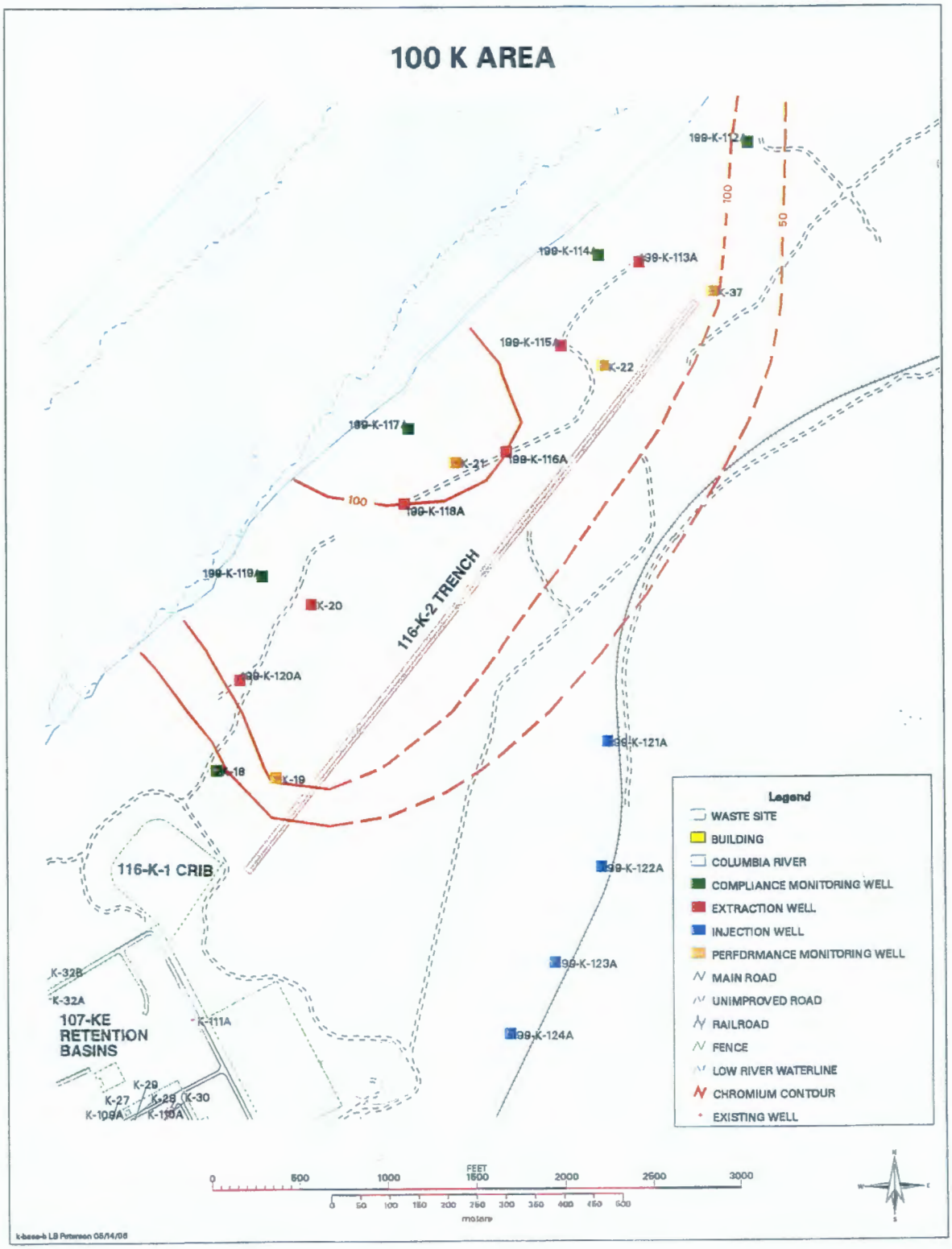


Figure 5-4. Groundwater Treatment System Sample Collection Points.

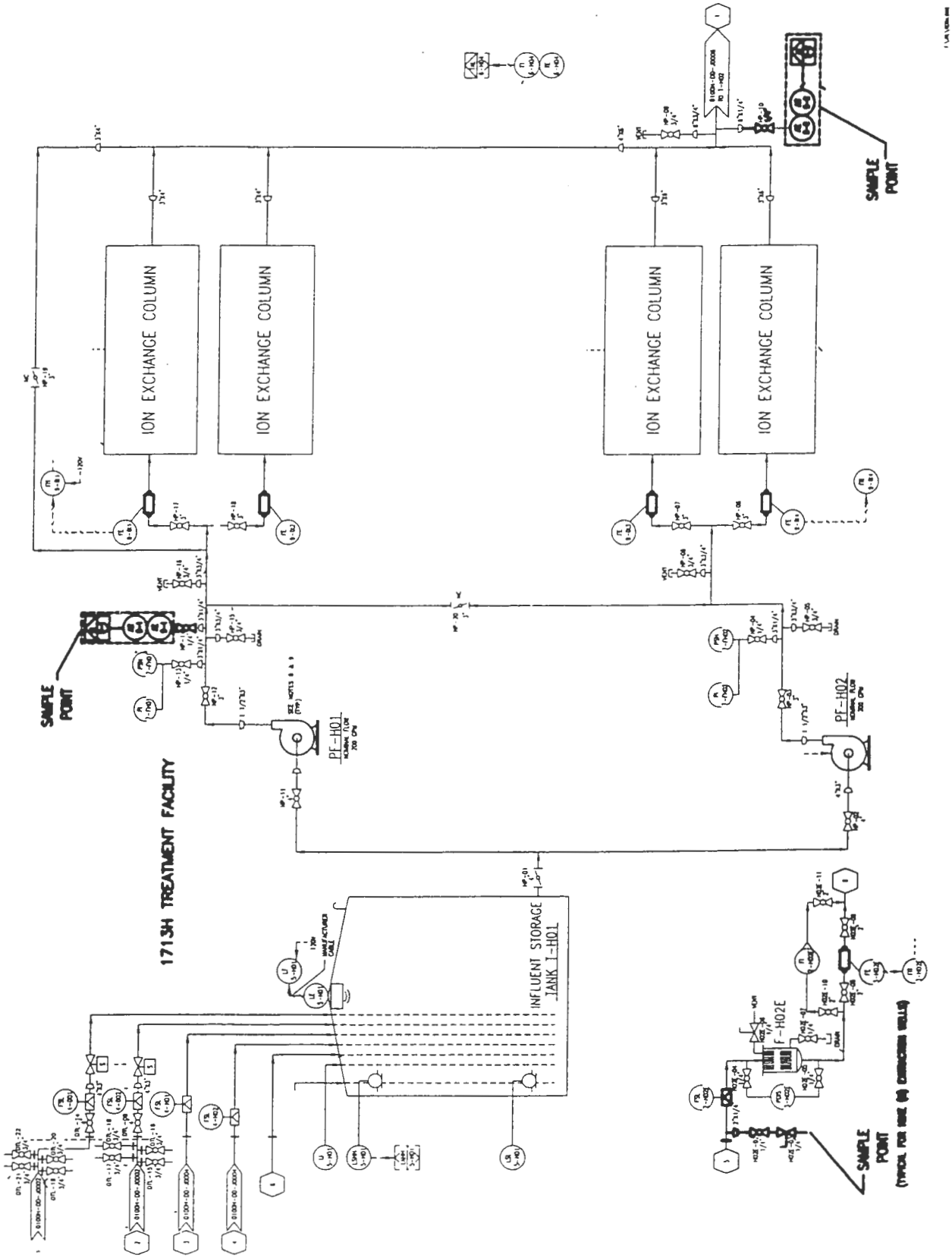


Table 5-1. 100-HR-3 Interim Action Monitoring Schedule. (sheet 1 of 2)

Sample Group	Pre-Startup September 1996 to March 1997			Startup April 1997 through June 1997			Operations July 1997 to End		
	Water Level	CR-Field	Co-contaminants[a]	Water Level	Cr-Field	Co-contaminants[a]	Water Level	Cr-Field	Co-contaminants[a]
Extraction Wells									
D8-53	M	X	X	M	M	--	Q	Q	SA
D8-54A	M	X	X	M	M	--	Q	Q	SA
H3-2A	M	X	X	M	M	--	Q	Q	SA
H4-7	M	X	X	M	M	--	Q	Q	SA
H4-11	M	X	X	M	M	--	Q	Q	SA
H4-12A	M	X	X	M	M	--	Q	Q	SA
H4-15A	M	X	X	M	M	--	Q	Q	SA
Injection Wells									
H3-3	M	X	X	M	--	--	Q	--	--
H3-4	M	X	X	M	--	--	Q	--	--
H3-5	M	X	X	M	--	--	Q	--	--
Compliance Wells									
D8-58	T	Q	--	M	M	--	Q	Q	--
D8-69	T	Q	--	M	M	--	Q	Q	--
D8-70	T	Q	--	M	M	--	Q	Q	--
H4-4	T	Q	--	M	M	--	Q	Q	--
H4-5	T	Q	--	M	M	--	Q	Q	--
H4-63	T	Q	--	M	M	--	Q	Q	--
H4-64	T	Q	--	M	M	--	Q	Q	--
Performance Wells									
D8-2	T	X	--	M	--	--	Q	SA	--
D8-3	T	X	--	M	--	--	Q	SA	--
D8-54B	T	X	--	M	--	--	Q	SA	--
D8-71	T	X	--	M	--	--	Q	SA	--
H4-3	M	X	--	M	--	--	Q	SA	--
H4-6	M	X	--	M	--	--	Q	SA	--
H4-8	T	X	--	M	--	--	Q	SA	--
H4-10	M	X	--	M	--	--	Q	SA	--

Table 5-1. 100-HR-3 Interim Action Monitoring Schedule. (sheet 2 of 2)

Sample Group	Pre-Startup September 1996 to March 1997			Startup April 1997 through June 1997			Operations July 1997 to End		
	Water Level	CR-Field	Co-contaminants[a]	Water Level	Cr-Field	Co-contaminants[a]	Water Level	Cr-Field	Co-contaminants[a]
H4-12B	M	X	--	M	--	--	Q	SA	--
H4-12C	M	X	--	M	--	--	Q	SA	--
H4-13	M	X	--	M	--	--	Q	SA	--
H4-14	M	X	--	M	--	--	Q	SA	--
H4-15B	M	X	--	M	--	--	Q	SA	--
H4-15C	M	X	--	M	--	--	Q	SA	--
H4-16	M	X	--	M	--	--	Q	SA	--
H4-17	M	X	--	M	--	--	Q	SA	--
H4-18	M	X	--	M	--	--	Q	SA	--
H4-45	M	X	--	M	--	--	Q	SA	--
H4-46	M	X	--	M	--	--	Q	SA	--
H4-48	M	X	--	M	--	--	Q	SA	--
H4-49	T	X	--	M	--	--	Q	SA	--
H5-1A	T	X	--	M	--	--	Q	SA	--
River	T	X	--	M	--	--	Q	SA	--
Treatment System									
Influent	--	--	--	--	W	--	--	CM	SA
Effluent	--	--	--	--	W	--	--	CM	SA

[a]Nitrate, strontium-90, technetium-99, tritium, and uranium.

CM = Chromium monitor
M = Monthly
Q = Quarterly
SA = Semiannually
T = Hourly transducer
W = Weekly
X = One-time event

Table 5-2. 100-KR-4 Interim Action Monitoring Schedule. (sheet 1 of 2)

Sample Group	Pre-Startup December 1996 to June 1997			Startup July 1997 through September 1997			Operations October 1997 to End		
	Water Level	CR-Field	Co-contaminants[a]	Water Level	Cr-Field	Co-contaminants[a]	Water Level	Cr-Field	Co-contaminants[a]
Extraction Wells									
K-113A	T	X	X	M	M	--	Q	Q	SA
K-115A	T	X	X	M	M	--	Q	Q	SA
K-116A	T	X	X	M	M	--	Q	Q	SA
K-118A	T	X	X	M	M	--	Q	Q	SA
K-119A	T	X	X	M	M	--	Q	Q	SA
K-120A	T	X	X	M	M	--	Q	Q	SA
Injection Wells									
K-121A	T	X	X	M	--	--	Q	--	--
K-122A	T	X	X	M	--	--	Q	--	--
K-123A	T	X	X	M	--	--	Q	--	--
K-124A	--	--	--	--	--	--	--	--	--
Compliance Wells									
K-18	T	Q	--	M	M	--	Q	Q	--
K-20	T	Q	--	M	M	--	Q	Q	--
K-112A	T	Q	--	M	M	--	Q	Q	--
K-114A	T	Q	--	M	M	--	Q	Q	--
K-117A	T	Q	--	M	M	--	Q	Q	--
Performance Wells									
K-19	M	A	--	M	--	--	Q	SA	--
K-21	T	A	--	M	--	--	Q	SA	--
K-22	T	A	--	M	--	--	Q	SA	--
K-37	M	A	--	M	--	--	Q	SA	--

Table 5-2. 100-KR-4 Interim Action Monitoring Schedule. (sheet 2 of 2)

Sample Group	Pre-Startup December 1996 to June 1997			Startup July 1997 through September 1997			Operations October 1997 to End		
	Water Level	CR-Field	Co-contaminants[a]	Water Level	Cr-Field	Co-contaminants[a]	Water Level	Cr-Field	Co-contaminants[a]
Treatment System									
Influent	--	--	--	--	W	--	--	CM	SA
Effluent	--	--	--	--	W	--	--	CM	SA

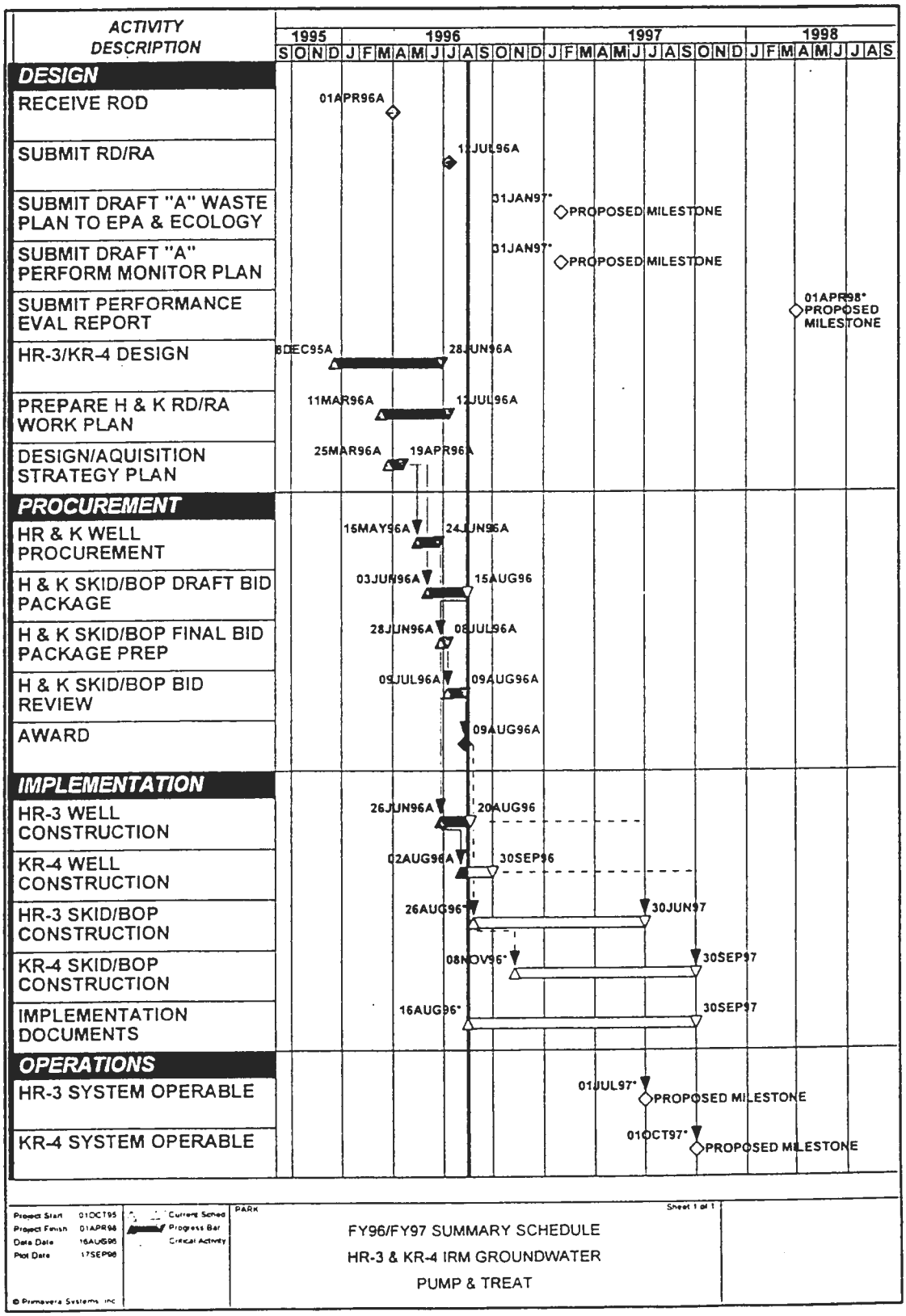
[a]Strontium-90 and tritium.

CM = Chromium monitor
M = Monthly
Q = Quarterly
SA = Semiannually
T = Hourly transducer
W = Weekly
X = One-time event

6.0 PROJECT SCHEDULE

The interim action will be implemented over the next several years. The schedule for interim action design, construction, and startup is provided in Figure 6-1. A more detailed schedule that will control construction activities will be developed as the project progresses. The construction schedule will be updated weekly and will become part of the project files after completion of construction activities. An operations schedule will be developed during construction.

Figure 6-1. FY 1996/FY 1997 Summary Schedule for 100-HR-3 and 100-KR-4 Interim Action Groundwater Pump and Treat.



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APPENDIX A

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR INTERIM ACTION DESIGN AND IMPLEMENTATION 100-HR-3 AND 100-KR-4 OPERABLE UNITS

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APPENDIX A

APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS FOR INTERIM ACTION DESIGN AND IMPLEMENTATION 100-HR-3 AND 100-KR-4 OPERABLE UNITS

A1.0 APPLICABLE OR RELEVANT AND APPROPRIATE REQUIREMENTS

The National Contingency Plan (NCP) and the interim action record of decision (ROD) require that the remedial actions described in this document comply with the applicable or relevant and appropriate requirements (ARARs) established in the interim action ROD. The purpose of this section is to discuss how each ARAR will be met during the remedial action. The discussions of ARAR compliance in this section apply to the interim action ROD.

All activities associated with the remedial action for the 100-HR-3 and 100 KR-4 Operable Units covered under the interim action ROD will occur "on site," as that term is defined under the NCP. As a result, the remedial actions described in this document need only meet the substantive requirements of the ARARs established in the interim action ROD.

A1.1 CHEMICAL-SPECIFIC ARARS

Chemical-specific ARARs typically are health- or risk-based numerical regulatory values or methodologies applied to site-specific media to establish cleanup criteria for remedial actions. The following ARARs establish contaminant-specific remedial action goals for the 100-HR-3 and 100-KR-4 Operable Units. The chemical-specific ARARS identified in the interim action ROD follow:

- Underground Injection Standards (WAC 173-218) and Underground Injection Control Program (40 CFR 144, Subpart B) for chromium are applicable to reinjection of treated groundwater. The authority to implement the federal program has been delegated to the state. The State's Underground Injection Control Program specifies procedures and practices applicable to the injection of fluids through wells. In particular, the regulation states that no fluids may be injected that result in a violation of any primary drinking water standards or that otherwise adversely affect the beneficial use of the aquifer. The primary drinking water standard for chromium, the primary contaminant of concern, is 100 ug/L. The treatment system is designed to reduce effluent chromium concentration to the maximum extent practicable in extracted groundwater. Concentrations of chromium will be less than the state drinking water standard before reinjection. To facilitate removal of the chromium, small quantities of chemicals (e.g., indicator chemicals associated with the sampling system) might be reinjected with the treated groundwater. Prior to using any new chemical, an evaluation will be made to

demonstrate that the chemical will not result in a violation of a drinking water standard or otherwise adversely affect the beneficial use of the groundwater.

- *Clean Water Act*, Ambient Water Quality Criteria for Protection of Aquatic Life (50 FR 30788, 40 CFR 131) and Water Quality Standards for Surface Waters of the State of Washington, (WAC 173-201A-040) are relevant and appropriate for establishing cleanup goals that are protective of the Columbia River. The standards presented are protective of freshwater aquatic organisms from chronic exposure to contaminants. One of the goals of the treatment system is to reduce levels of chromium in the groundwater that discharges to the river to meet these standards.

A1.2 ACTION-SPECIFIC ARARS

Action-specific ARARs typically are technology or activity-based regulatory requirements or limitations triggered by a particular action such as treatment, transport, and/or disposal of hazardous waste. The action-specific ARARs established in the interim action ROD are identified below along with a discussion explaining how the ARARs will be met during implementation of the remedial action.

- State of Washington Dangerous Waste Regulations (WAC 173-303) are applicable for the identification, treatment, storage, and disposal of wastes determined to be dangerous wastes. It is not anticipated that there will be dangerous waste generated as part of the 100-HR-3 and 100-KR-4 remedial action; however, if dangerous waste is generated it will be handled in accordance with WAC 173-303.

- Land Disposal Restrictions (40 CFR 268) The federal land disposal restrictions (LDRs) prohibit land disposal of hazardous waste unless those wastes are treated to meet LDR standards or a treatability variance is obtained. The State's LDR regulations incorporate the Federal RCRA LDR requirements (currently maintained under Federal authority). If any wastes generated under the interim remedial action are determined to be dangerous wastes, the waste will be treated as necessary to meet the LDR treatment standard of 5 mg/L (Toxic Characteristic Leaching Procedure [TCLP]) for chromium prior to disposal at ERDF. Wastes that already meet the LDR standards may be land disposed at ERDF.

- Minimum Standards for Construction and Maintenance of Wells (WAC 173-160): The State's Minimum Standards for Construction and Maintenance of Wells are applicable for the location, design, construction, and abandonment of resource protection (i.e., extraction, reinjection, and monitoring) wells. Section 5.2 of this document presents the requirements considered for the monitoring system design. The 100-HR-3 and 100-KR-4 Pump-and-Treat Drilling Description of Work (DOW) includes well design specifications for both system and monitoring wells that meet the standards set forth in WAC 173-160 (BHI 1996a). The DOW was received and approved by the

U.S. Department of Energy (DOE) and conditionally approved by the regulatory agencies. In addition, WAC 173-162 requires certification of drilling contractors and operators. The BHI prequalification process for procurement requires proof of certification from all drilling contractors prior to bid submittal.

- Dangerous Waste Standards for Tank System Units (WAC 173-303-640): The substantive requirements of this code are relevant and appropiate to the construction, operation, maintenance, and closure of any tanks and associated components (e.g., piping) that contain dangerous waste associated with both the water treatment system and the resin stabilization system. The tank system requirements specify requirements for system design when dangerous waste is associated with the system. The effluent treated in the system has been shown (i.e., historical groundwater data) to be below the regulatory limits used to designate dangerous waste. Therefore, the requirements of WAC 173-303-460 did not impact the design of the water treatment plant. Ion-exchange resin in the system concentrates chromium; however, the resin is a process material and not a waste until spent and removed from the system.

A1.3 LOCATION-SPECIFIC ARARS

Location-specific ARARs are restrictions placed on hazardous substance concentrations or remedial actions based on the specific location of the substance or action. The location-specific ARARs established in the interim action ROD are discussed below.

- National Archeological and Historical Preservation Act (16 USC Section 469); 36 CFR Part 65, is applicable to recover and preserve artifacts in areas where an action may cause irreparable harm, loss, or destruction of significant artifacts. The interim remedial action occurs in potential culturally sensitive areas. An initial cultural resources review was completed prior to site activity to minimize impacts to cultural resources. No specific mitigation measures were identified for the 100-HR-3 Operable Unit. However, using information from the cultural resources review, a mitigation plan for protection of cultural resources has been developed specifically for the 100-KR-4 Operable Unit because a specific cultural site was identified. The plan outlines a strategy that will be followed to mitigate impacts to cultural resources in the 100-KR-4 Operable Unit. In addition, a cultural resource specialist will be available on site during all earth-disturbing activities. If artifacts or other indicators of cultural significance are noted, all work at that location will be stopped and a site-specific evaluation, including tribal authorities as appropriate, will be performed to determine whether further actions to preserve artifacts are necessary.

- *National Historic Preservation Act* (16 USC 470, *et. seq.*); 36 CFR Part 800, is applicable to actions in order to preserve historic properties controlled by a federal agency. During the initial cultural resources review, the sites were also evaluated for

historic properties. No historic properties were identified in the vicinity of the remedial action.

- Public Law 100-605, To Authorize a Study of the Hanford Reach of the Columbia River and for Other Purposes is applicable to planning, designing, and locating activities in a manner that minimizes direct and adverse effects on the values for which the river is under study. The location of any facilities within 1/4 mile of the river will be coordinated with the National Park Service. DOE will contact and provide the necessary information to inform the National Park Service of the planned activities within a quarter mile of the Columbia River.

- Endangered Species Act of 1973 (16 USC 1531 *et. seq.*, 50 CFR Parts 200 and 402): The Endangered Species Act requires that Federal agencies consult with the Department of Interior to ensure that actions they authorize, fund, or implement do not jeopardize the continued existence of endangered or threatened species or adversely affect their critical habitat. Several listed and candidate endangered or threatened species have been identified in and around the Hanford Site. The remedial actions described in this document will be managed so these species existence will not be jeopardized, nor will their habitat be adversely affected. An ecological resource review will be completed prior to beginning site activity to identify the presence of threatened, endangered, or sensitive species and habitat. If species or habitat are identified, construction and operation plans will be modified as necessary on a case-by-case basis to minimize impacts to the species or habitat. In addition, an ecological resource specialist will perform periodic site visits during construction and operation to evaluate changes in the local ecological conditions. If any threatened, endangered, or sensitive species are noted during these visits, appropriate actions will be taken on a case-by-case basis.

- Migratory Bird Treaty Act is relevant and appropriate to protection of migratory birds in the areas. As part of the ecological reviews, described above, impacts to migratory birds will be evaluated. If migratory birds impacts are identified, appropriate actions will be taken, which may include consultation with the U.S. Fish and Wildlife Service.

- Bald and Golden Eagle Protection Act of 1985 is applicable due to the known roosting of bald eagles in the general vicinity of potential extraction wells. The ecological resources review will be conducted and guidelines will be established to prevent impacts to eagles during the project. Guidelines have been established in the *Bald Eagle Site Management Plan for the Hanford Site, South Central Washington* (DOE-RL 1994). This plan was developed with consultation from the U.S. Department of Interior.

A1.4 OTHER CRITERIA, ADVISORIES, OR GUIDANCE TO BE CONSIDERED

To be considered (TBC) information generally consists of Federal, State, and local criteria, advisories, and proposed standards that are not legally binding (i.e., are not promulgated regulations), but that may be useful in establishing cleanup goals or remedial alternatives that are protective of human health and the environment. The TBCs identified in the interim action ROD are discussed below.

- Floodplain Management Executive Order (E.O. 11988) and Protection of Wetlands Executive Order (E.O. 11990) are relevant and appropriate to activities within the floodplains and wetlands. To the extent practicable, actions should avoid or minimize the impact to floodplains and wetlands, and minimize loss due to floods. The only activity that will occur in floodplains is the use of drive points, which will be used to evaluate near river groundwater concentrations. Drive points were selected to minimize impacts to the floodplains. No activities will occur in wetlands.

- ERDF Waste Acceptance Criteria (WAC)(BHI 1996b): Waste acceptance criteria (e.g., concentration limits and waste form limitations,) have been developed for the ERDF. This document provides the primary requirements that waste must meet in order to be accepted at the ERDF. At a minimum, the waste generated from the construction and operation of the pump-and-treat system must not contain free liquids or exceed toxic characteristic leaching procedures levels listed in the WAC. Waste Management is further described in Appendix D.

A2.0 REFERENCES

BHI, 1996a, *100-HR-3 and 100-KR-4 Pump-and-Treat Drilling Description of Work*, BHI-00770, Rev. 0, Bechtel Hanford, Inc., Richland, Washington.

BHI, 1996b, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, BHI-00139, Rev. 2, Bechtel Hanford, Inc., Richland, Washington.

DOE-RL, 1994, *Bald Eagle Site Management Plan for the Hanford Site, South-Central Washington*, DOE/RL-94-150, Rev. 0, U.S. Department of Energy, Richland Operations Office, Richland, Washington.

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APPENDIX B

NUMERICAL MODELING

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APPENDIX B

NUMERICAL MODELING

B1.0 DEVELOPMENT OF NUMERICAL GROUNDWATER MODELS

To support the interim action design process, numerical groundwater models were developed for each of the three areas of the interim action: one each of the 100-H and 100-D Areas of the 100-HR-3 Operable Unit and one of the 100-KR-4 Operable Unit. The numerical models were used to help determine the placement of new wells and the use of existing wells to support the interim action. The numerical modeling was also used to estimate extraction and injection rates for interim action design purposes.

Numerical modeling was performed using the Micro-Fem™ finite element program package. This package includes the preprocessing mesh-generating programs, the calculation module, and postprocessing programs. The mesh-generating program allows the user to construct irregularly shaped and variably spaced finite element triangular meshes. This feature allows for high resolution of the finite element mesh near pumping or injection centers. The calculation module supports either transient or steady-state solution. The postprocessing program enables the user to export the results of the calculations for presentation. The Micro-Fem™ package was chosen for the numerical modeling because the package programs have the capability to (1) generate a finite element mesh, (2) perform transient and steady-state solution applications, and (3) generate graphical output.

B2.0 MODEL BOUNDARIES

Sections B2.1 through B2.3 describe the model boundaries for each of the three areas.

B2.1 100-H AREA

Figure B-1 shows the model grid used for the 100-HR-3 H Area interim action design modeling. Note the high density of points in the areas of greatest interest. The Columbia River formed the eastern model boundary for the 100-H Area. Naturally occurring hydrologic boundaries do not exist in the other directions. Consequently, the remaining three model boundaries were located far enough from the area of interest that hydraulic changes caused by withdrawal and injection would not be evident at the boundary. To the west, the boundary was located parallel to prevailing water table contour lines. To the north and south, the boundaries were located perpendicular to the prevailing water table contour lines (i.e., parallel to the hydraulic gradient).

To the west, where the water table remains fairly constant throughout the year, the boundary was assumed to be constant head. Because groundwater flow was assumed to occur parallel to and not across the northern and southern boundaries, these boundaries were assigned to be no flow. The Hanford/Ringold Formation contact served as the bottom of the model. The model only considered flow through the aquifer contained within the Hanford formation.

B2.2 100-D AREA

Figure B-2 shows the model grid used for the 100-D Area design modeling. The Columbia River formed the northwestern model boundary for the 100-D Area. All other model boundaries were constant head due to the hydrogeology of the area. A flow divide occurs through the 100-D Area. Recharge from Gable Mountain, Gable Butte, and the gap between the two and recharge from Umtanum Ridge discharges into the Columbia River at 100-D Area and all across the horn. Consequently, recharge appears to occur almost directly south of the two 100-D Area reactor buildings. The constant head values were initially interpreted from the June 1995 water table map in the *Resource Conservation and Recovery Act of 1976* (RCRA) Annual Report (DOE-RL 1995a).

B2.3 100-KR-4 OPERABLE UNIT

Figure B-3 shows the model grid used for the 100-KR-4 Operable Unit interim action design modeling. The Columbia River formed the northern model boundary for the 100-KR-4 Operable Unit. Naturally occurring hydrologic boundaries do not exist in the other directions. Consequently, the remaining three model boundaries were artificially constructed and located away from the extraction and injection areas to minimize boundary influences in those areas. The boundaries perpendicular to the river were designated no flow because the prevailing flow lines are essentially perpendicular to the river. The inland boundary roughly parallel to the river was constant head.

B2.4 NUMERICAL TREATMENT OF COLUMBIA RIVER BOUNDARY

The river and the aquifer were assumed to be connected vertically. If the hydraulic head of the groundwater exceeded the river stage elevation, flow exited the model. If the river stage elevation exceeded the hydraulic head of the groundwater, flow entered the model. The rate at which the flow entered or exited the model depended on the hydraulic head difference and the vertical resistance between the aquifer and the river. The vertical resistance term is purely empirical and was determined solely through calibration of the models. The river stage was assumed to be constant. Attempting to incorporate the stage trends and fluctuations of the Columbia River was considered too complex for the purpose of this modeling. For similar reasons, bank storage effects were simply assumed to be included in the vertical resistance term between the groundwater and the river.

B3.0 MODEL INPUT PARAMETERS

The input parameters required for the modeling are the aquifer transmissivity and porosity, the hydraulic head at the constant head boundaries, and the saturated thickness of the aquifer. Hydraulic gradients for all three areas were variable.

B3.1 100-H AREA

Transmissivity values were based on the saturated thickness of the Hanford formation and measurements of hydraulic conductivity. Figure B-4 shows the distribution of transmissivity used in the model. Note the decrease in transmissivity in the areas north and east of the 183-H Solar Evaporation Basins. The elevation of the Hanford/Ringold Formation contact rises about 3 m (10 ft) in this area. Consequently, the saturated thickness of the Hanford formation decreases to less than 1 m (3 ft) near the basins. Elsewhere, the saturated thickness ranges between approximately 3 to 5.4 m (10 to 21 ft). Previous estimations of aquifer hydraulic conductivity developed from slug and constant discharge testing and the results of the Ferris analysis indicate that the average hydraulic conductivity is around 30 m/day (100 ft/day) (Tyler 1996); therefore, this value is used in the model. The hydraulic head in the river was estimated from measurements taken at the 100-H river gauge and an assumed river gradient of 0.00023 m/m. The porosity was assumed to be 0.20.

To calibrate the model, the boundary conditions were modeled to steady state. The results of the steady-state simulation were compared to the average hydraulic heads in the 100-H Area wells measured from January 1994 to August 1995. The only parameter that was varied was the resistance term used to connect the river and the groundwater. Figure B-5 shows the results of the model calibration. Where measured data exist, the model and measured contours are generally in good agreement, especially near the river. Away from the river where few wells exist, the contours of the model results and measured data do not coincide as well. The gradient of the modeled data appears greater than the gradient determined from the water level measurements. As can be seen from Figure B-5, well control for the purpose of water table mapping only exists in a small area compared to the model grid.

B3.2 100-D AREA

The Ringold Upper Mud Unit forms the bottom of the unconfined aquifer at 100-D. The geologic information available indicates that the unconfined aquifer thickness ranges between 2 and 6 m (5 and 20 ft). Few data are available to map the thickness, so it was assumed to be uniform (5 m [16 ft]) throughout the model. Most of the unconfined aquifer is contained within the Ringold Gravel Unit E, but the aquifer exists in both the Hanford formation and Ringold Gravel Unit E near wells D8-55 and D5-17. The transmissivity was uniform throughout most of the model except where the aquifer exists in both Hanford formation and Ringold Gravel Unit E.

In these two spots, the hydraulic conductivity in the model was the weighted average of the hydraulic conductivity of the Ringold Gravel Unit E and the Hanford formation. The average was weighted based on the saturated thickness of both formations estimated from drilling logs and the average water table elevation.

Existing hydraulic conductivity and transmissivity data in the 100-D Area are limited. Analysis of slug tests performed at several 100-D Area wells screened in the Ringold Formation ranged between 3 and 18 m/day (10 and 60 ft/day) (DOE-RL 1993). Transmissivity estimates based on pump-and-treat data collected at wells D5-14, D5-15, and D5-16 indicated that the transmissivity is about 112 to 204 m^2/day (1,200 to 2,200 ft^2/day) (DOE-RL 1995b). For an aquifer 5 m (16 ft) thick, the resulting hydraulic conductivity is 24 to 44 m/day (80 to 150 ft/day). For the model, the hydraulic conductivity of the Ringold Gravel Unit E is 15 m/day (49 ft/day). Slug tests at D8-53 and D8-54A and an infiltration test conducted at the 116-DR-1 Trench indicated that the hydraulic conductivity of the Hanford formation ranges between 122 and 162 m/day (400 and 530 ft/day) (DOE-RL 1993). For the model, the hydraulic conductivity of the Hanford formation is 170 m/day (560 ft/day). Nowhere in the model is the aquifer entirely contained within the Hanford formation. The transmissivity distribution used in the model is shown in Figure B-6. Except in the vicinity of wells D8-55 and D5-17, the transmissivity in the model is 75 m^2/day (807 ft^2/day). Near well D8-55 the transmissivity ranges up to 675 m^2/day, and near well D5-17 the transmissivity ranges up to 750 m^2/day, depending on the saturated thickness of the Hanford formation. The porosity, which was required for the velocity field calculations, was assumed to equal 0.2.

The constant head values were initially interpreted from the June 1995 water-table map in the RCRA Annual Report (100-D Ponds) (DOE-RL 1995a). The head values computed under steady state conditions were compared to water level data collected between June 1993 and May 1995. The boundary conditions were then adjusted to calibrate the calculated hydraulic heads to the measured values (Figure B-7).

B3.3 100-KR-4 OPERABLE Unit

The uppermost unconfined aquifer at 100-KR-4 is contained within the Ringold Gravel Unit E, with silty or clayey Paleosol and overbank deposits forming the bottom. Few of the boreholes extend completely through the Ringold Gravel Unit E, but the geologic information available indicates that the unconfined aquifer thickness is fairly uniform. Aquifer hydraulic conductivity data are limited. Slug testing was performed in wells installed during the limited field investigation and in wells installed in 1994. Except for well K-37, all of those wells were installed near the reactor buildings or retention basins and not in the area of concern (i.e., near the trench). The slug test hydraulic conductivity results from the limited field investigation wells ranged between 5.8 and 44 m/day (19 and 145 ft/day) (DOE-RL 1994). Slug test results from five of the wells installed in 1994 ranged between 0.98 and 9.8 m/day (3.2 and 32.1 ft/day) (Lindberg 1995). Constant discharge testing occurred in 1996 at several wells along the trench, and the geometric mean of the transmissivity determined from those tests was about 90 m^2/day

(960 ft^2/day). The Ferris method analysis (McMahon and Peterson 1992) performed on data collected in the southern part of 100-N also indicated an aquifer transmissivity of 90 m^2/day. Based on the information available, the aquifer thickness and hydraulic conductivity were considered uniform throughout the model area. The hydraulic conductivity of the Ringold Gravel Unit E was 7.4 m/day (24 ft/day) and the saturated thickness was 12.2 m (40 ft). The porosity, which was required for the velocity field calculations, was assumed to be 0.2.

The constant head values were initially estimated from the June 1995 water table map in Serkowski et al. (1996). The head values computed under steady-state conditions were compared to water level data collected between June 1993 and May 1995. The boundary conditions were then adjusted to calibrate the calculated hydraulic heads to the measured values (Figure B-8).

B4.0 MODELING RESULTS

For each area, a number of scenarios were developed for simulation. The scenarios were successively modified based on results of iterative model simulations and in an effort to conceptually optimize pump-and-treat system performance. Because of the highly variable saturated thickness in the 100-H Area model, simulations for that area were performed under transient conditions. Performing transient simulations allowed the model to account for and include changes in the transmissivity caused by drawdown or buildup. Considering that the aquifer thickness thins to less than 1 m (3.28 ft) in certain places, small changes in the hydraulic head would result in significant changes in the transmissivity. Drawdown and buildup of the water table caused by the different pump-and-treat configurations were simulated for a 5-year time span. The 100-D and 100-K model simulations were performed to steady state. The initial aquifer thickness for both models was uniform, and changes in the aquifer thickness were not considered significant compared to the original thickness.

Streampaths and capture zones for 100-H were based on the resulting 5-year hydraulic velocity field. Streampaths and capture zones for 100-D and 100-K were based on the resulting steady-state velocity fields. Streampaths are the paths followed by the groundwater in the aquifer. Capture zones show the area of the aquifer from which the individual extraction wells draw water. Groundwater contained within or crossing a contour closed around two or more extraction wells becomes trapped. Trapped groundwater is then either captured by one of the extraction wells or becomes stagnant. Streampaths crossing the river boundary line were terminated at that line and assumed to represent paths of river recharge.

B4.1 100-H AREA

Eight modeling scenarios using five different extraction and injection well networks were simulated for the 100-H Area and are presented in detail in Tyler (1996). The intent and

effectiveness (as determined by the model) of each simulation are briefly discussed here and summarized in Table B-1. Scenario 1 included only near-river extraction to provide the most immediate reduction of the quantity of chromium entering the Columbia River. This scenario indicated what the optimal pumping rate for the near-river wells is to eliminate or reverse the hydraulic gradient at the river, without inducing so much river recharge that the expected influent chromium concentration would be below practical treatable levels. Based on the modeling results, the optimal pumping rate of the near-river wells is about 38 L/min (10 gal/min). Scenario 2 examined the possibility of optimizing the system for mass removal by pumping from well H4-7 and a new well located in the high-concentration area. While this configuration does provide a consistently higher influent concentration for a longer period of time, this configuration provides virtually no immediate impact at the river, and may not prevent chromium from discharging into the river during its operational life. Scenarios 3 and 4 incorporated both elements of immediate near-river relief and sustained influent chromium concentrations by pumping the near-river wells and well H4-7. Scenario 4 included the injection of treated effluent from 100-D Area. The inclusion of the additional treated effluent required that the injection wells be placed farther away from the extraction wells to prevent recirculation from occurring too rapidly and short-circuiting the extraction wells from the contaminated portion of the aquifer. Scenario 5 included the extraction wells of scenarios 3 and 4 with the additional new well described in scenario 2. The additional well was added so that if the influent concentration of any of the near-river wells falls below practical treatable levels, those wells can be taken off-line without reducing the flow rate below a practical level. An additional simulation was then performed showing the outcome of shutting off all three near-river extraction wells and pumping only from well H4-7 and the new well. This simulation was different from scenario 2 only because it included the additional effluent from 100-D Area.

Because of the decontamination and decommissioning activities associated with the 183-H Solar Evaporation Basin Facility, drilling the new extraction well where indicated in the modeling presented in Tyler (1996) became unrealistic. Furthermore, field inspection of the proposed injection area showed it preferable to locate it approximately 200 m north and 100 m east of the original modeled location for topographical and infrastructure reasons. Scenario 5 was then revisited using well H3-2A in place of the new extraction well and relocating the injection well field as described. Scenario B-1 includes all five extraction wells; scenario B-2 includes only extraction wells H4-7 and H3-2A.

Figure B-9 shows the resulting water table contours and capture zones of the first simulation. Only about 4% of the influent should be induced from the river within 0.5 to 1 year. The remainder of the streampaths originate at the injection wells. Recirculation between wells H4-11 and H4-12A and the injection wells occurs after about 4 years. Recirculation between well H4-15A does not occur for over 11 years and is not considered to be a factor during the lifespan of this interim action. Based on the streampaths and water table contours, no water is expected to discharge from the groundwater into the river between the near-river extraction wells. Wells H4-7 and H3-2A both establish recirculation cells with the injection wells. Well H3-2A begins extracting treated water within about 1.5 years. The streampaths terminating at well H4-7 originate at both injection wells. About half of the influent water pumped from well H4-7 will

be diluted by recirculation in about 3 years, and the other portion of the groundwater will not become diluted by recirculation for about 8 years.

Removing the near-river wells from the extraction network does not change the recirculation time greatly for the two upgradient wells, but the streampaths do spread out laterally (Figure B-10). In fact, one of the streampaths terminating at well H4-7 does not recirculate with either of the injection wells. The influent dilution percentages of the upgradient extraction wells remain fairly close to those calculated for the preceding simulation. The overall concentration of chromium in the influent water should be higher, because these extraction wells are located where the concentration of chromium is higher. Once recirculation occurs, the chromium concentrations will decrease.

B4.2 100-D AREA

Modeling of the 100-D Area resulted in an interim action design that includes extraction from two wells, D8-53 and D8-54A, and injection of the 100-D water in the 100-H Area. Figure B-11 shows the result of pumping wells D8-53 and D8-54A at 151 L/min (40 gal/min). The capture zone of the two wells extends laterally across the entire plume area. Pumping at this rate induces significant recharge. After about 2 years, 33% of the influent should come from the river. Table B-2 presents the expected chromium concentration at each well. The concentration of the groundwater entering the wells was assumed to be the same as it was where it originated in the aquifer. The concentration of the river recharge was assumed to be 0, and the minimum groundwater concentration outside the 50-µg/L isopleth was assumed to be 25 µg/L. After 5 years, the chromium concentration of the influent water should remain constant for the foreseeable future of the interim action.

B4.3 100-KR-4 OPERABLE UNIT

Five modeling scenarios were performed for the interim action proposed for 100-KR-4. The modeling scenarios were developed in accordance with the directive to delete well K-20 from the extraction well network and to locate proposed well K-120A as far away from the sensitive area as possible. The first simulation shows the results of pumping the remaining five new extraction wells at 95 L/min (25 gal/min) each. The second scenario is similar to the first, except that proposed well K-118A is located closer to the boundary of the sensitive area. The third scenario includes the five wells of the first scenario with an additional extraction well located near the trench, about half way between proposed wells K-118A and K-120A. The fourth scenario includes the five wells of the first scenario with two additional extraction wells located near the trench, equally spaced between proposed wells K-118A and K-120A. The fifth scenario uses constant flow (instead of constant head) conditions along the upgradient boundary to determine the sensitivity of the model to the different types of boundary conditions. The well field of simulation 1 was used to compare the results. Table B-3 provides a summary of the extraction

and injection wells used in each simulation. These new modeling scenarios incorporated the latest information regarding the coordinates of the proposed extraction and injection wells.

Figure B-12 shows the results of the first scenario. Four of the five extraction wells induce river recharge, and none of the extraction wells establish recirculation cells with the injection wells in less than 7 years. The extraction well network should capture the unconfined aquifer along the river from about half way between well K-20 and well K-118A and the northernmost proposed compliance monitoring well within 5 years. Groundwater between the captured area, well K-120A, and the river may become immobilized, but will not be captured. The concentration of chromium in the effluent water should remain near the level in the groundwater for at least 2 years. After that, the concentration should decrease as the extraction wells begin drawing the river recharge into the effluent. Table B-4 provides a summary of the expected concentration of the effluent.

Figure B-13 shows the results of the second scenario. Because of the size of the model and the scale of the figure, moving the extraction well results in only a subtle change in the results. Compared to the previous scenario, one less streampath terminating at well K-116A originates at the river, but one more streampath terminating at well K-118A originates at the river. Other than that, the results from scenarios 1 and 2 are virtually indistinguishable. The results of scenario 2 are also summarized in Table B-4.

Scenario 3 includes the extraction wells from simulation 1 with an additional well located along the trench about halfway between wells K-120A and K-118A. Figure B-14 shows the results of this scenario. The additional extraction well does not induce any river recharge or draw groundwater from near the river. The well does enhance the hydraulic performance of the rest of the system. The areal extent of the aquifer immobilized or captured by the pump and treat is greater than in scenario 1 and includes almost all of the groundwater currently situated between the trench and the river. The system of wells does not appear to induce more river recharge than the two previous scenarios, but the new extraction well does establish a recirculation cell with the injection well field much more quickly than the other wells (about 5 years). Table B-5 provides a summary of the expected concentration of the effluent. Scenario 4 includes the extraction wells from simulation 1 with two additional wells equally spaced between wells K-120A and K-118A and located along the trench. No major change in the performance of the system compared to scenario 3 during its expected lifetime can be seen (Figure B-15), except that well K-118A appears to induce about twice as much river recharge as before. The captured/immobilized area appears to be no larger than before, but the certainty of capture/immobilization is greater. Table B-6 provides a summary of the expected concentration of the effluent.

The fifth scenario was performed as a sensitivity analysis of the model to changing the upgradient boundary conditions from constant head to constant flow. The constant flow values used along the boundary were determined from the calibration performed for the constant head simulation. The same extraction and injection well system modeled in scenario 1 was used to compare results. Figure B-16 shows the results of the model run. The change in boundary conditions results in very little change of the streampaths around the extraction wells. Most of

the hydraulic change occurs around the outside of the area impacted by the pump-and-treat system. Furthermore, the hydraulic gradient directly between the injection and extraction wells is approximately the same, regardless of the boundary condition type. On the basis of these results, either boundary condition appears acceptable for the purpose of this modeling.

The five well extraction systems of scenarios 1 and 2 appear capable of preventing most of groundwater located between the trench and the river from discharging into the river. However, certain areas between wells K-18 and K-19 and the river may continue discharging into the river even during operations. The addition of an extraction well along the trench between wells K-120A and K-118A results in the captured/immobilized area of the aquifer extending the entire length of the trench. Because the primary objective of the interim action is to prevent or reduce the quantity of chromium that is discharging into the Columbia River, scenario 3 appears to be the preferred alternative (see Figure B-14).

B5.0 REFERENCES

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Figure B-1. 100-H Area Model Grid.

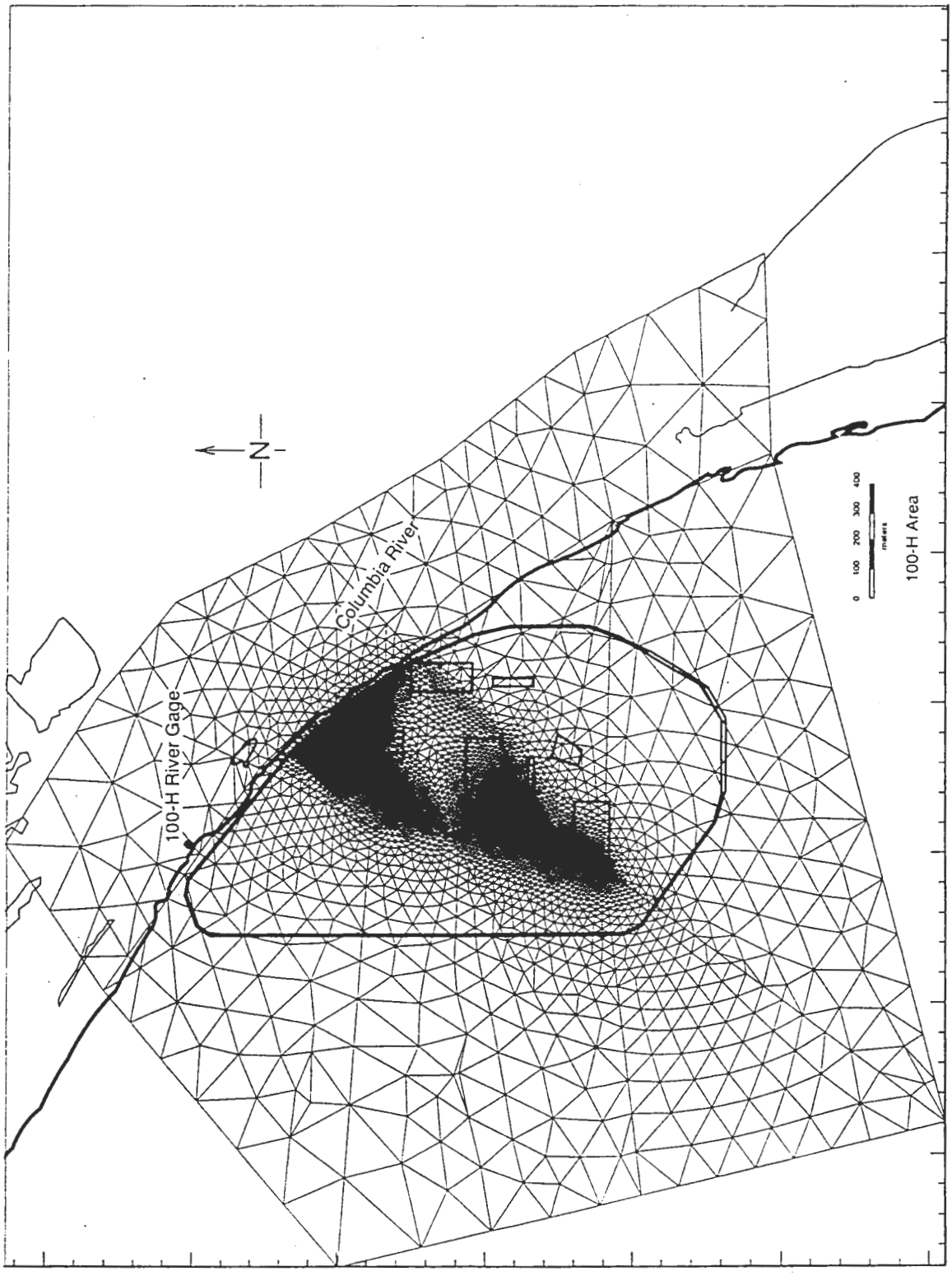


Figure B-2. 100-D Area Model Grid.

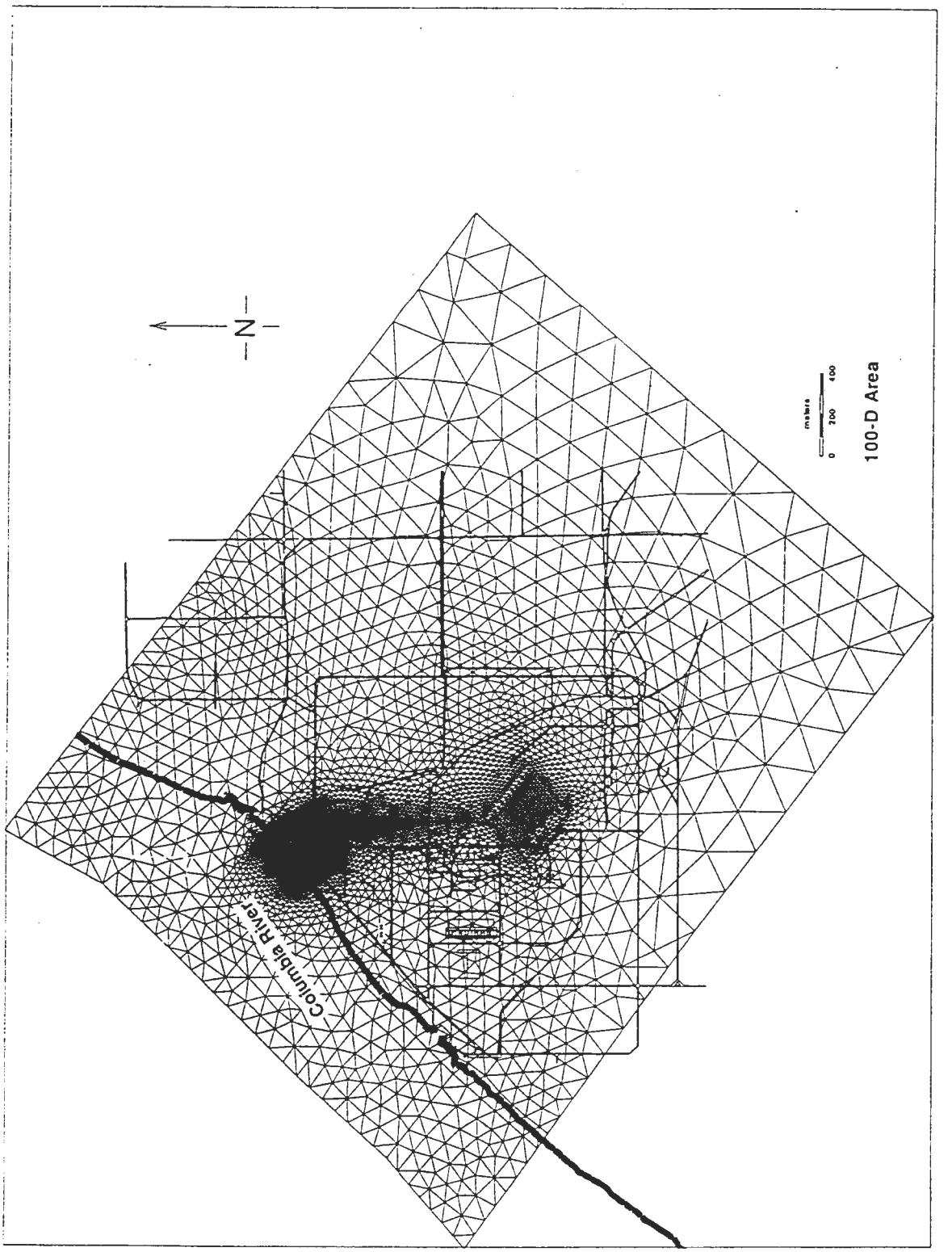


Figure B-3. 100-K Area Model Grid.

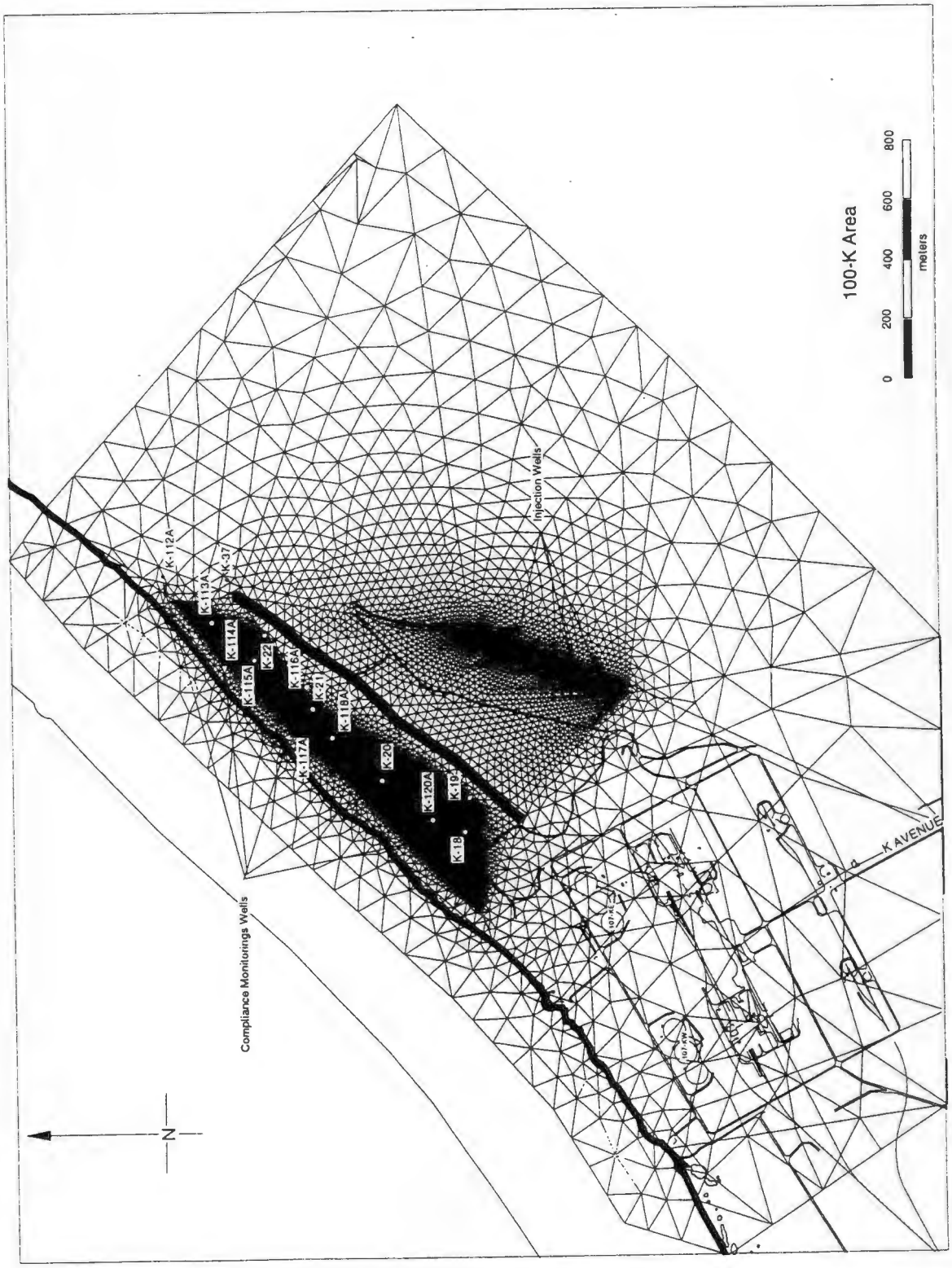
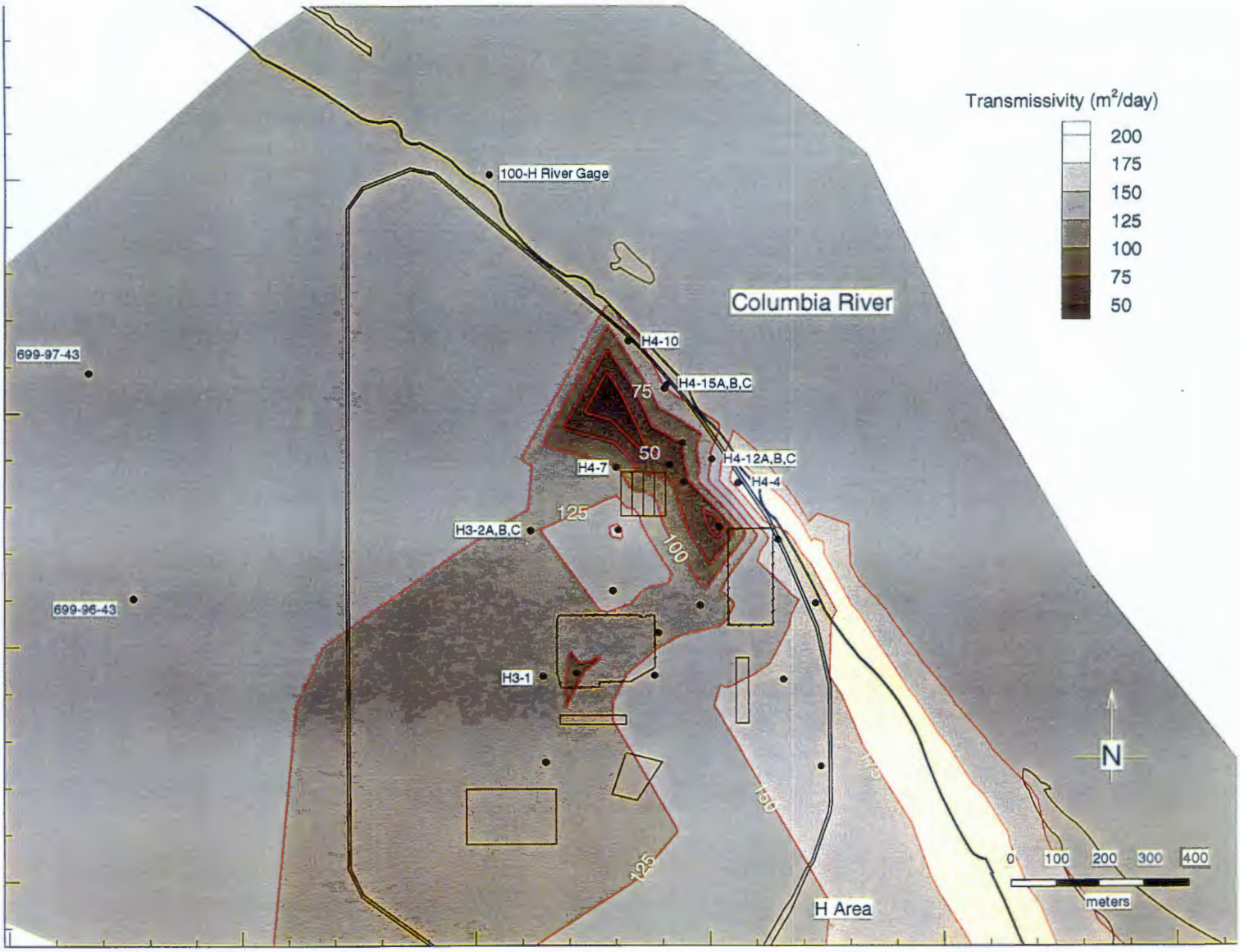


Figure B-4. 100-H Area Transmissivity Distribution.



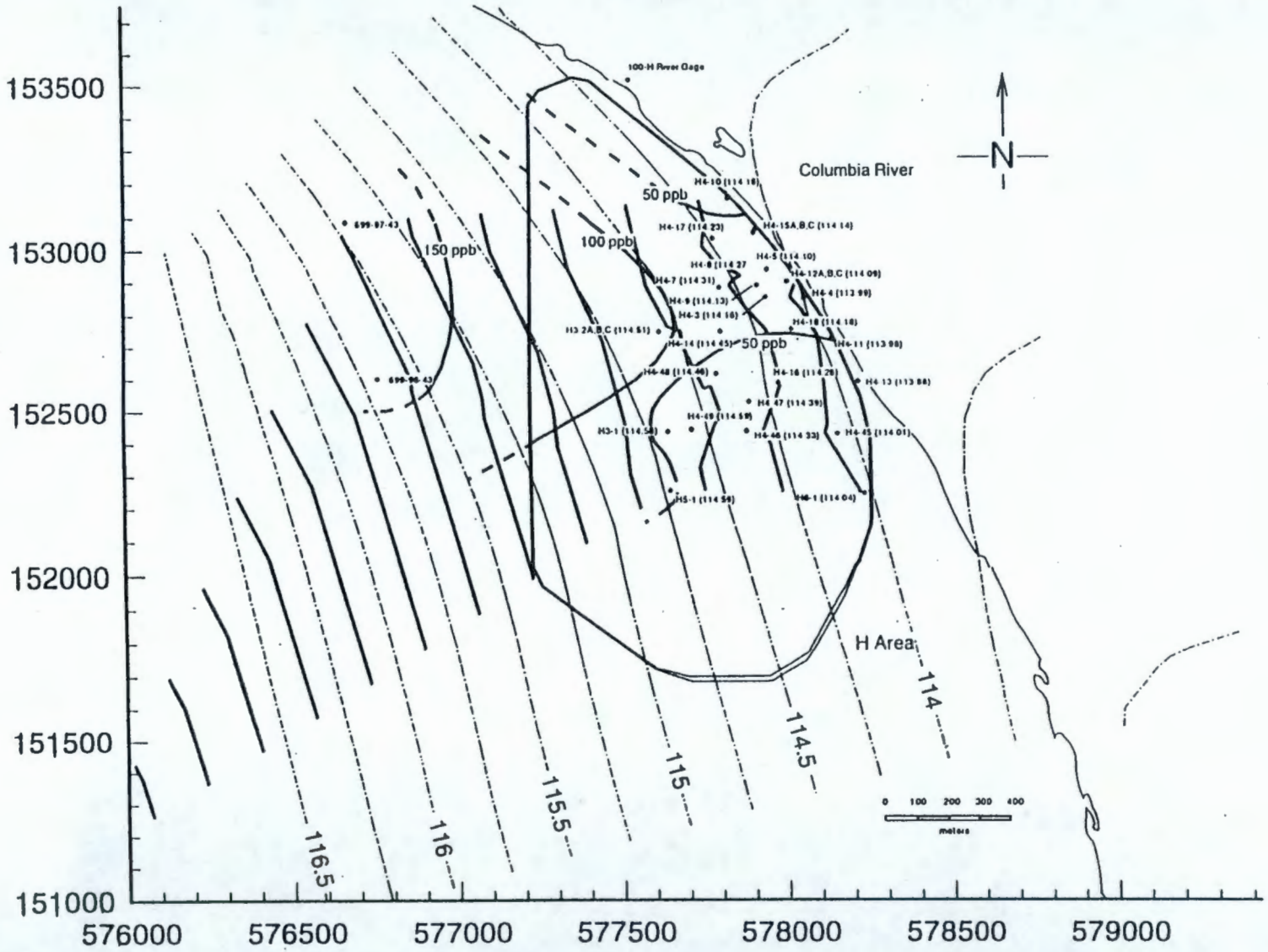


Figure B-5. 100-H Area Model Calibration Results.

Figure B-6. 100-D Area Transmissivity Distribution.

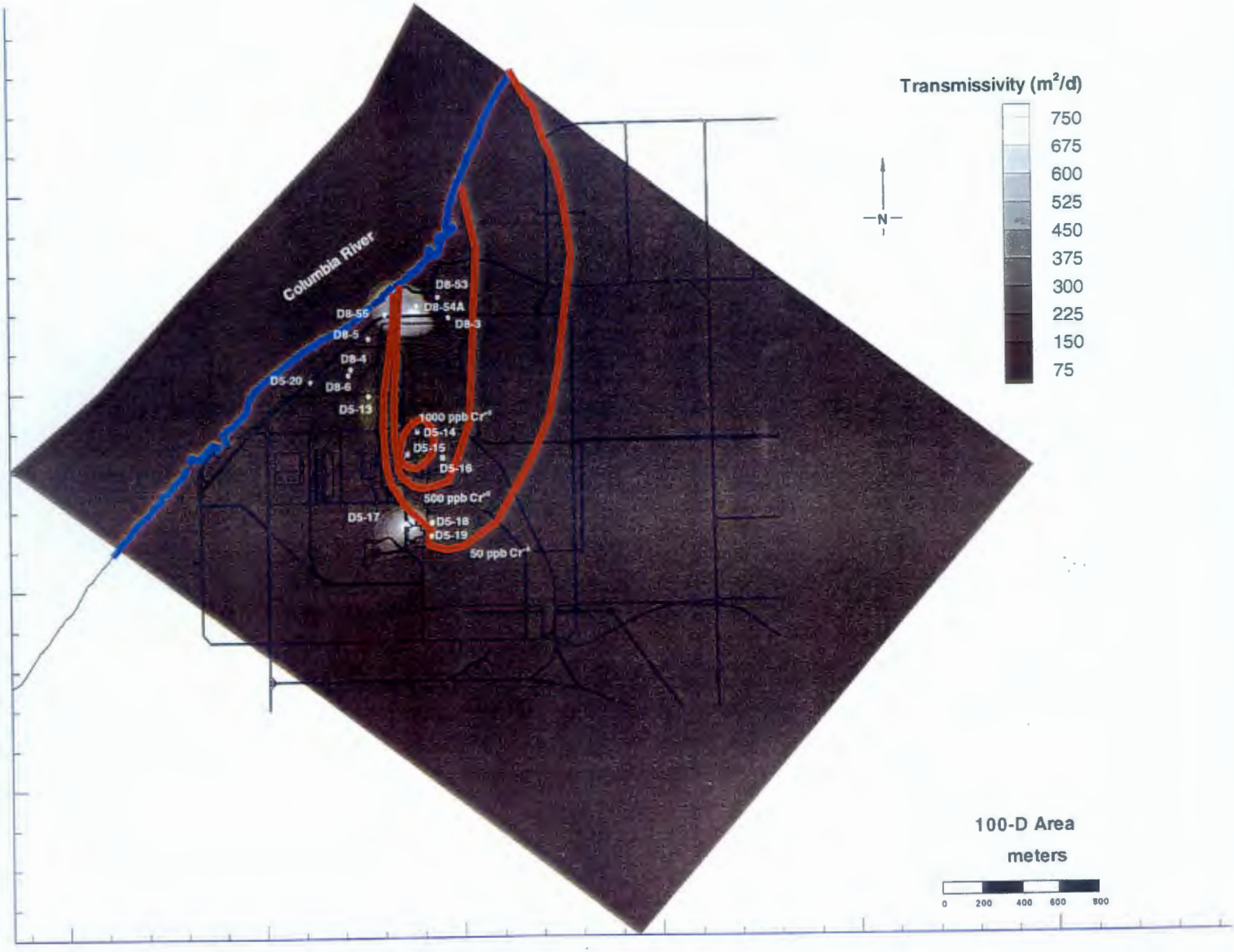


Figure B-7. 100-D Area Model Calibration Results.

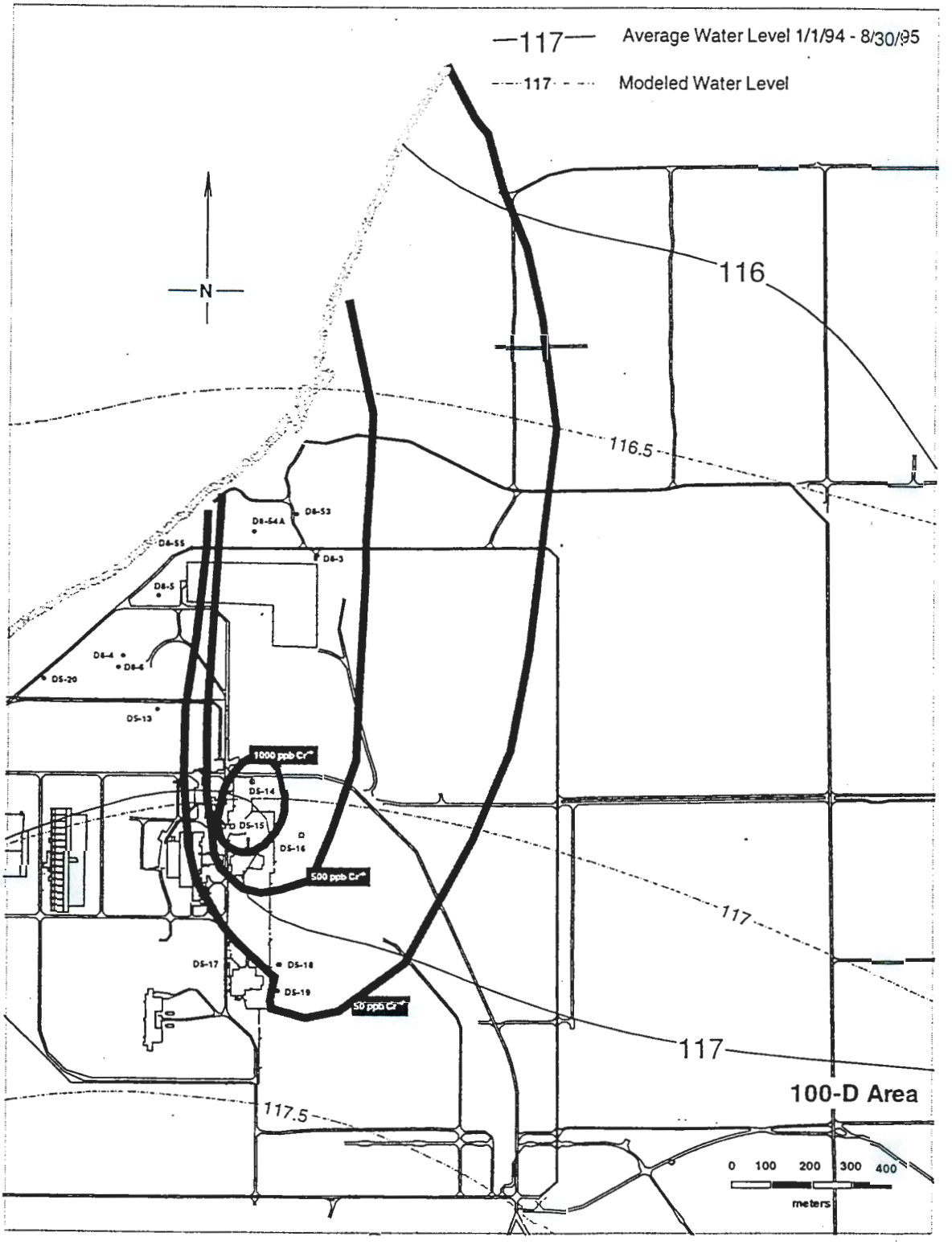


Figure B-8. 100-KR-4 Model Calibration Results.

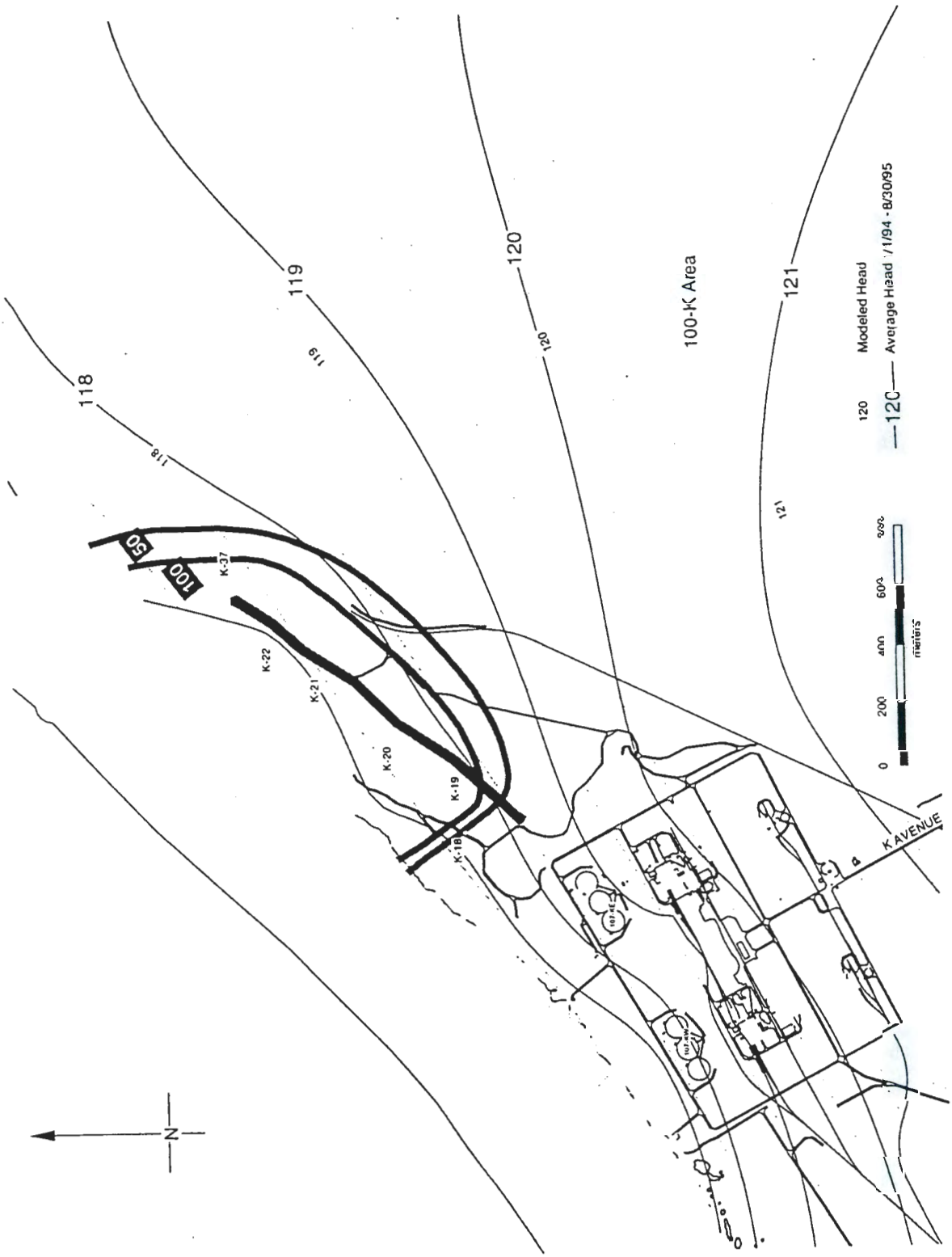


Figure B-9. 100-H Area Modeling Results for New Scenario 1.

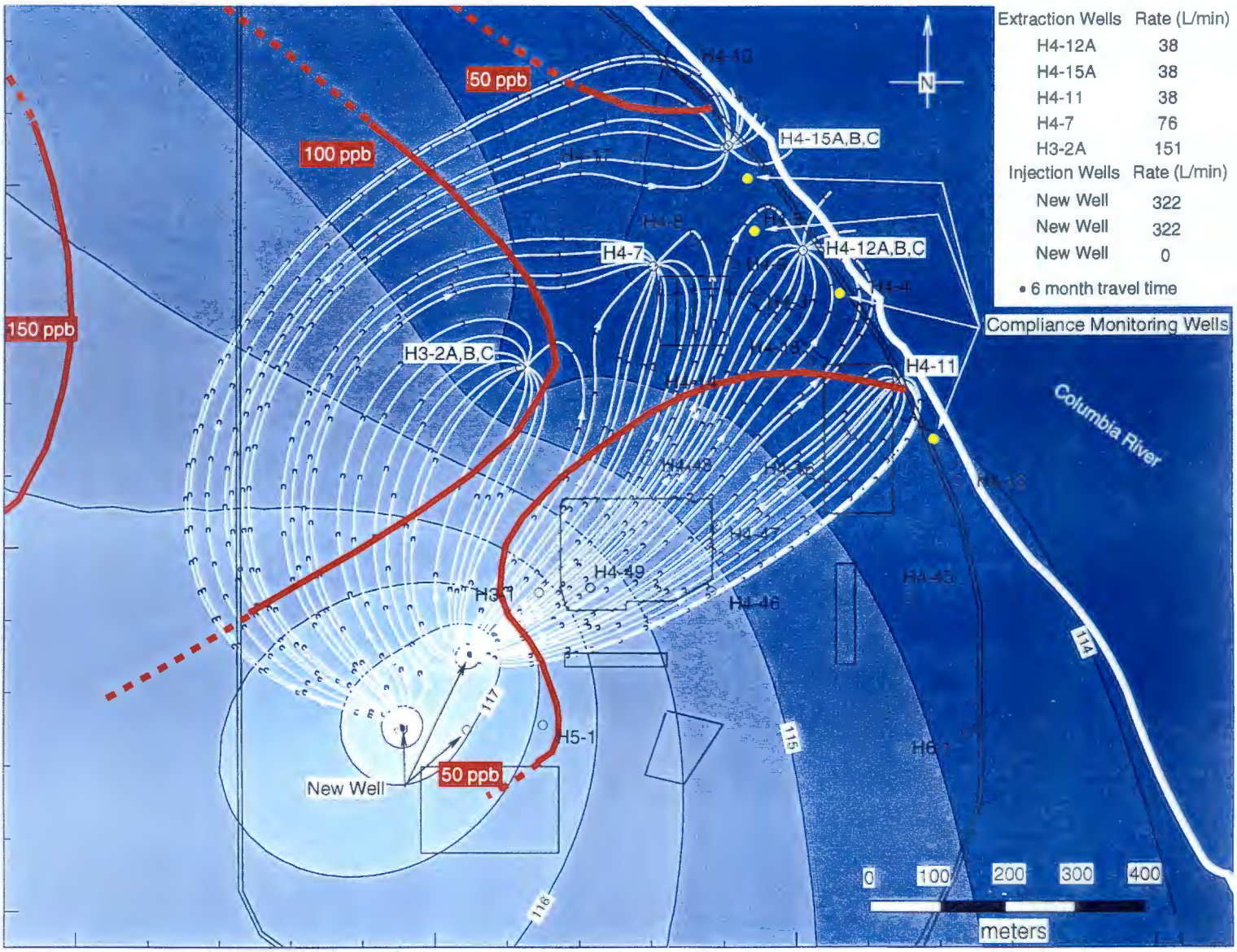


Figure B-10. 100-H Area Modeling Results for New Scenario 2.

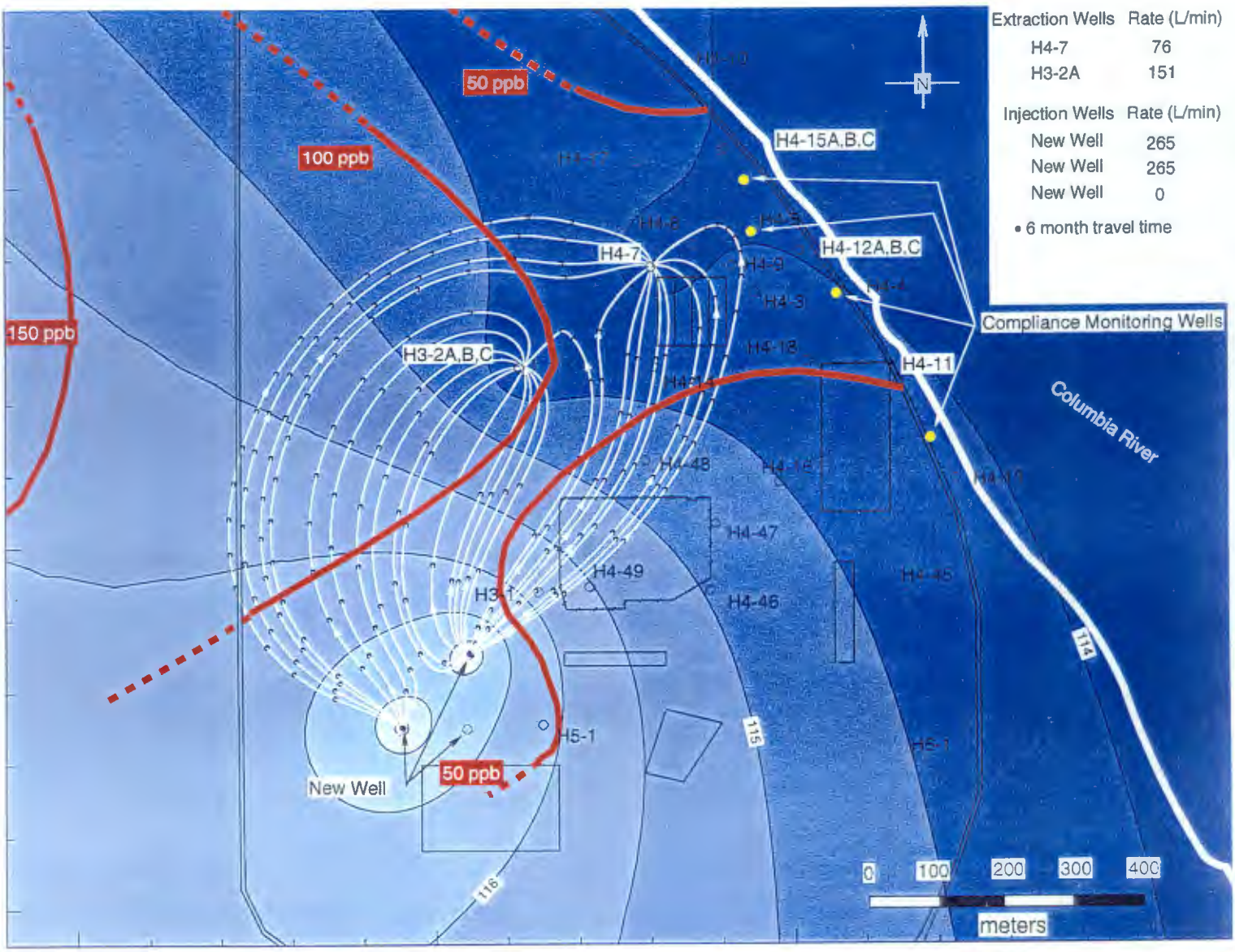


Figure B-11. 100-D Area Modeling Results.

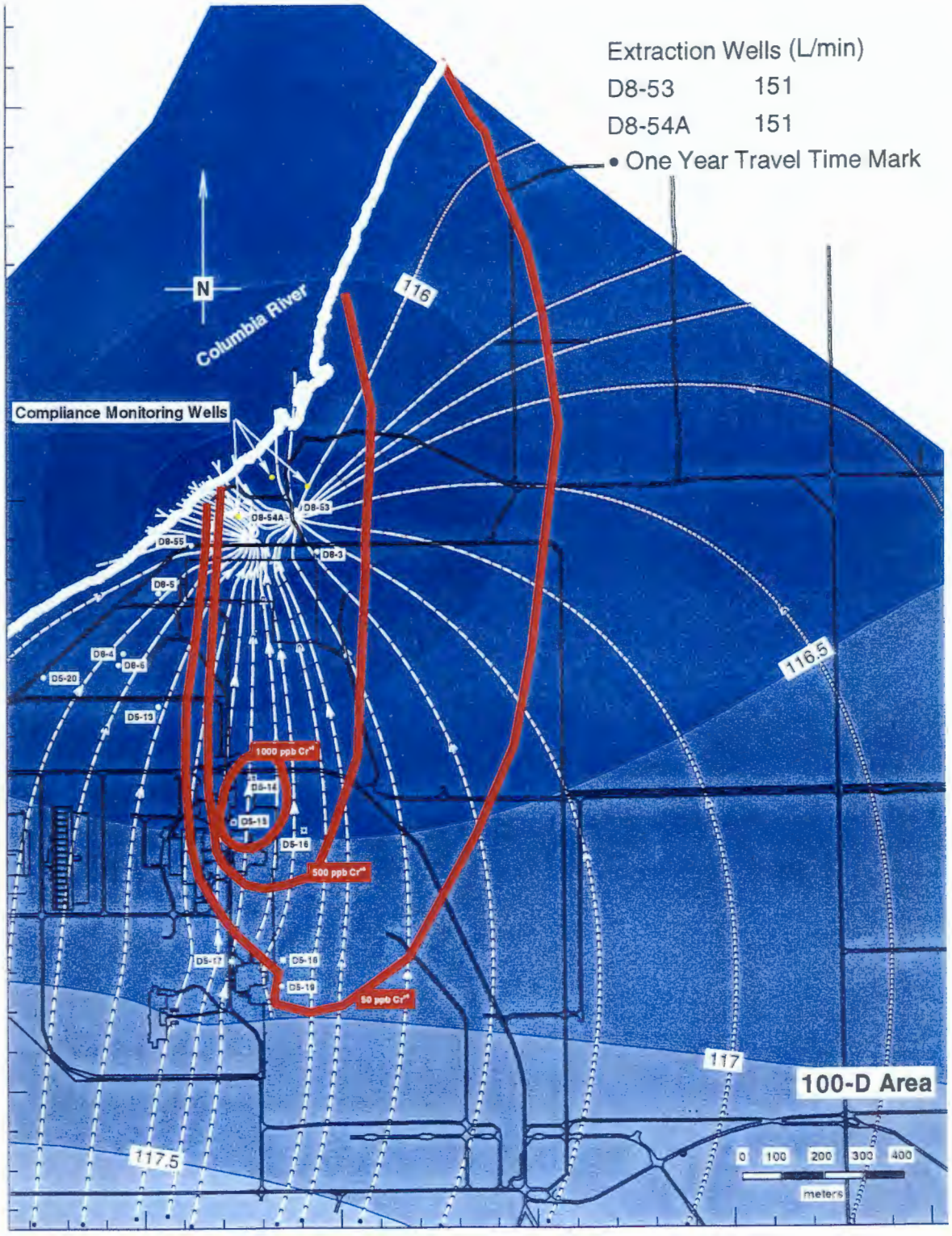


Figure B-12. 100-KR-4 Modeling Results for Scenario 1.

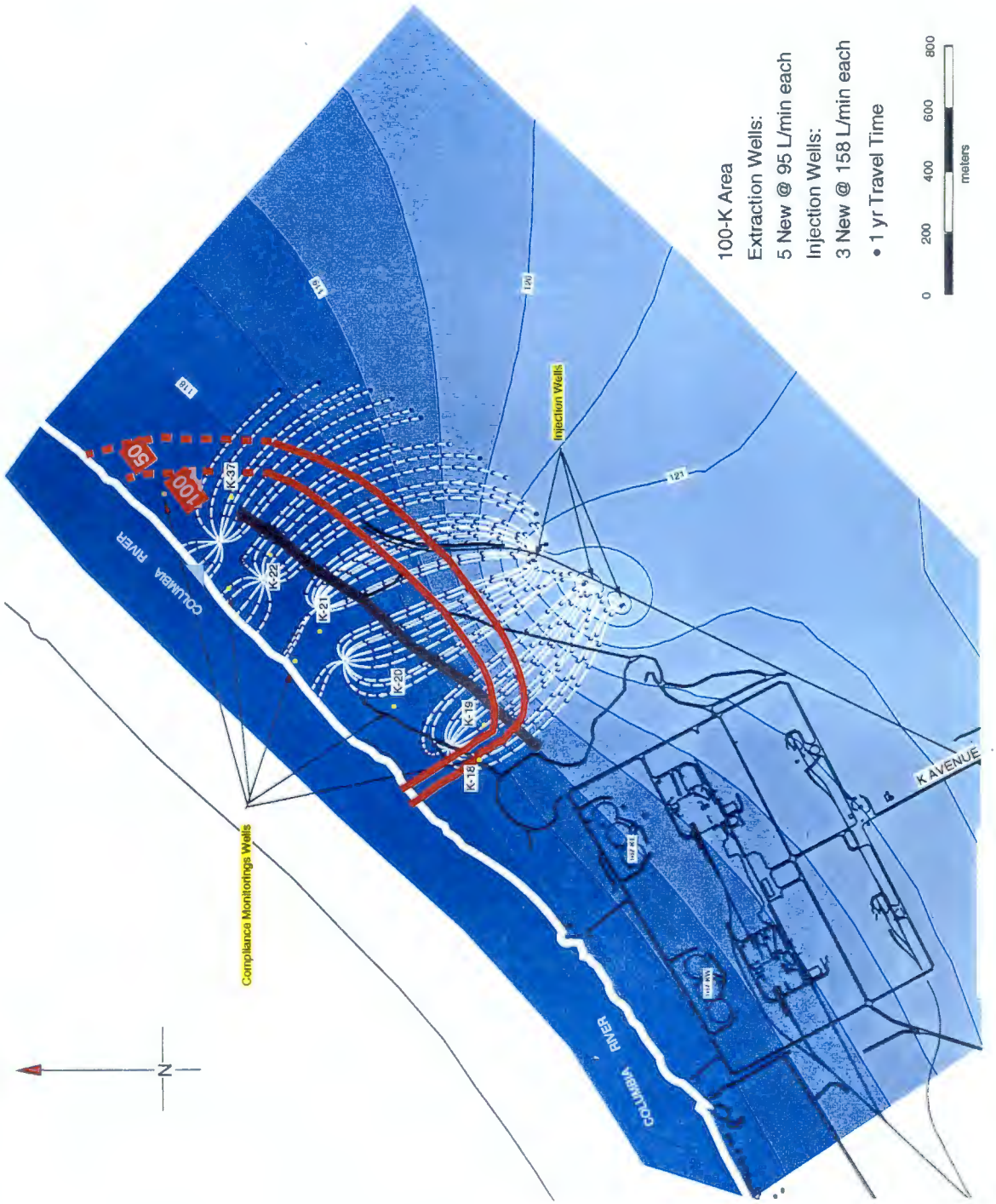


Figure B-13. 100-KR-4 Modeling Results for Scenario 2.

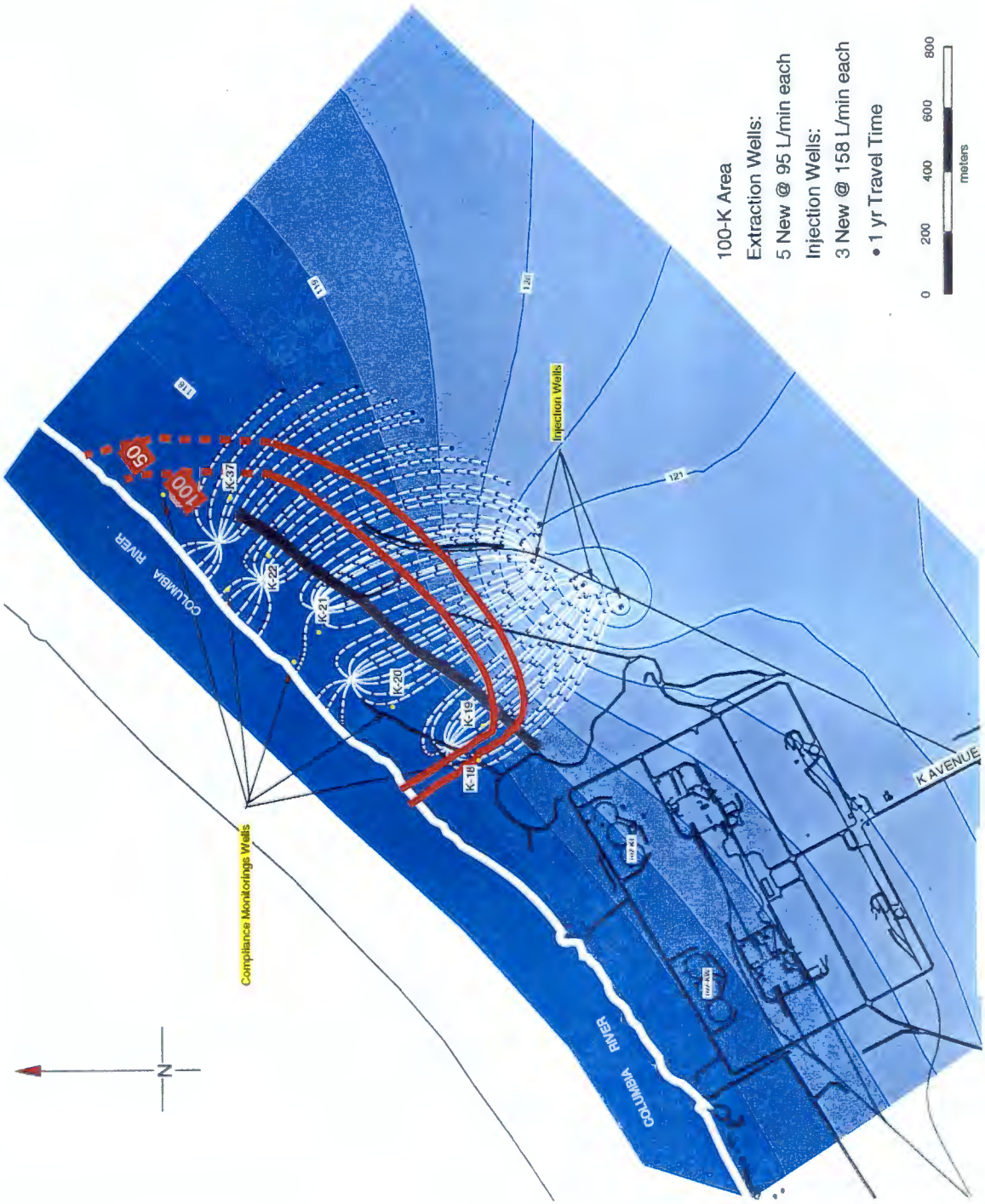


Figure B-14. 100-KR-4 Modeling Results for Scenario 3.

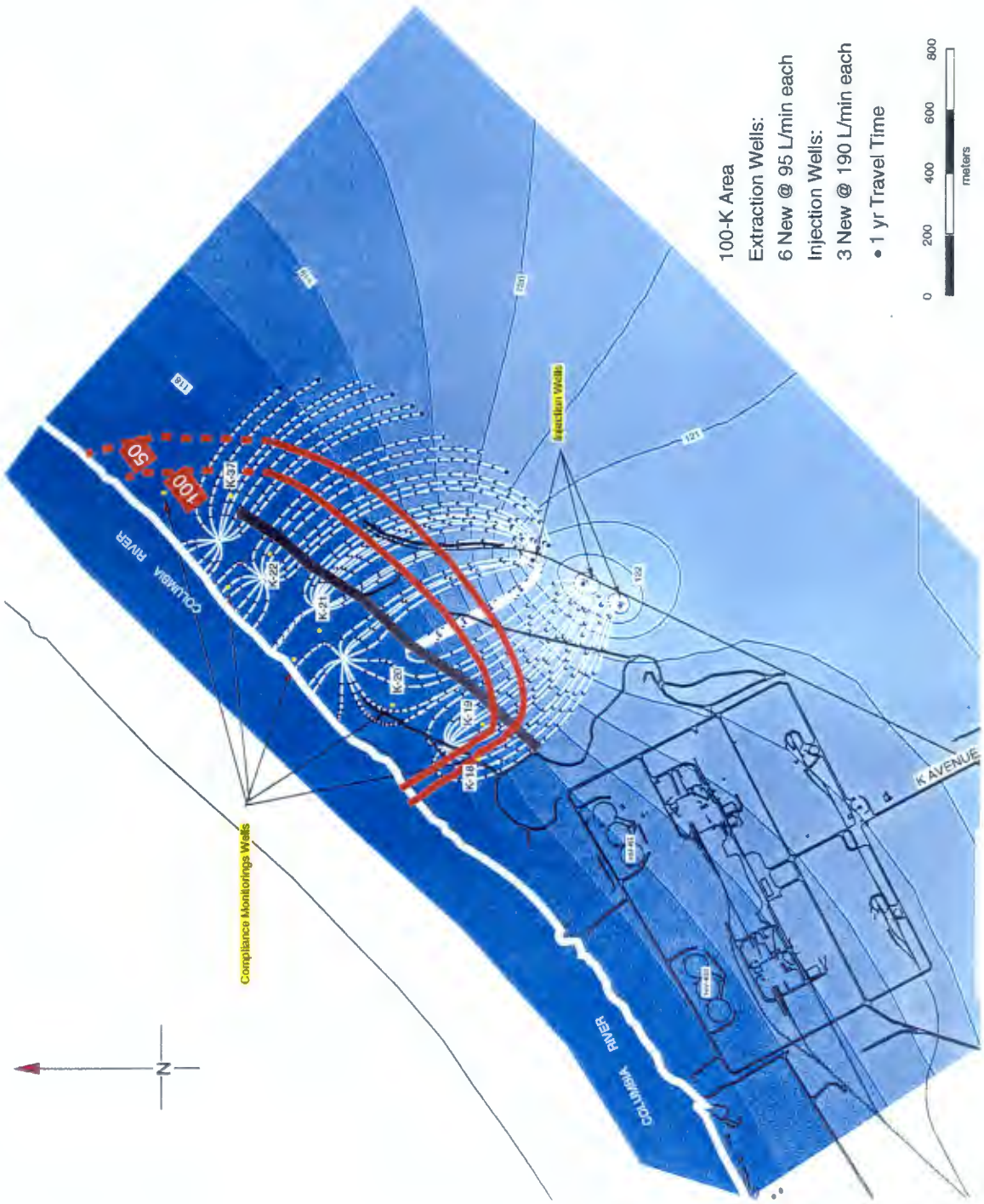


Figure B-15. 100-KR-4 Modeling Results for Scenario 4.

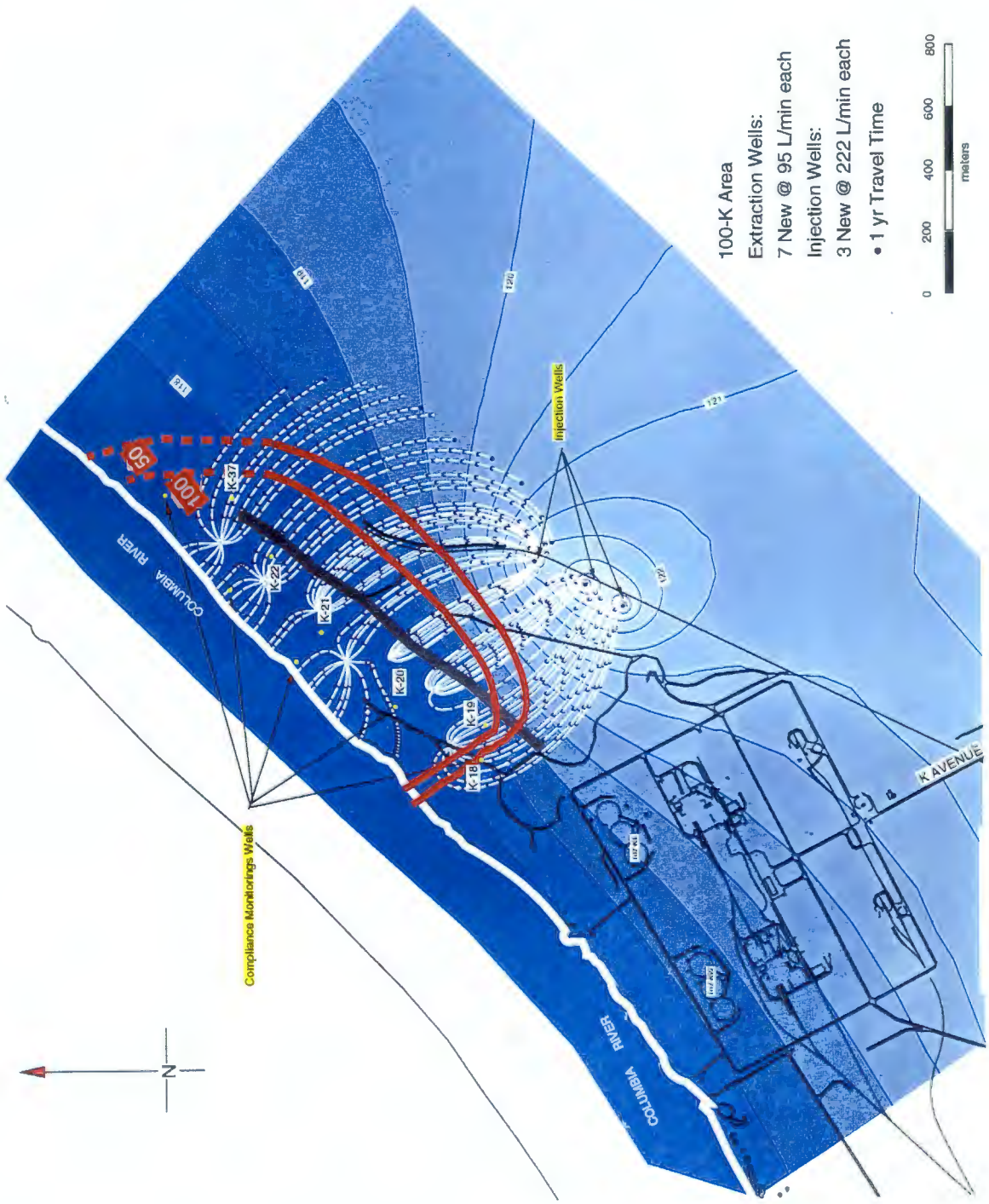


Figure B-16. 100-KR-4 Modeling Results for Scenario 5.

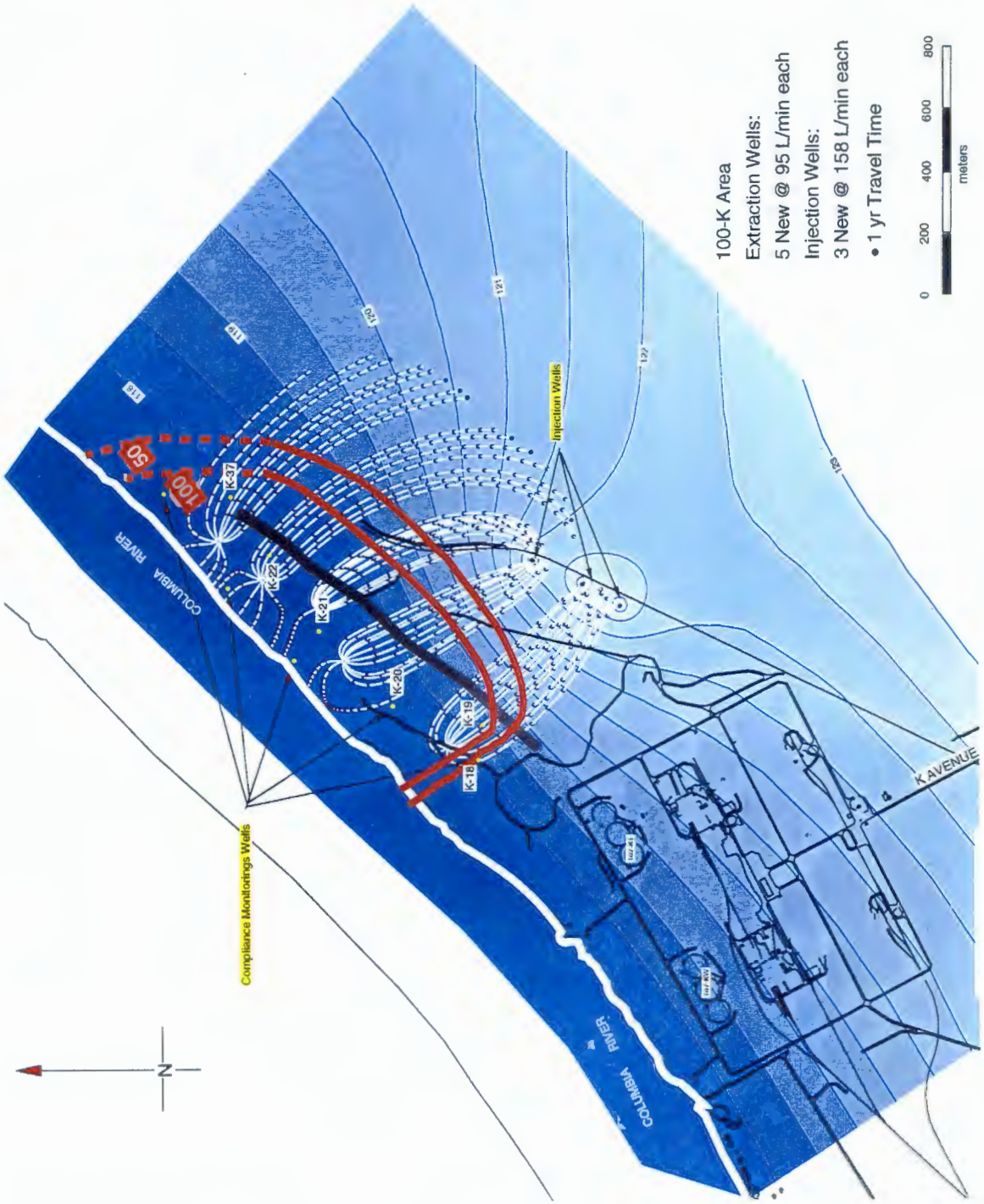


Table B-1. Numerical Modeling Simulations. (sheet 1 of 2)

Operable Unit and Scenario	Extraction Wells	Purging Rate (gal/min)	Estimated Cr(VI) Conc. (µg/L)	Injection Well	Injection Rate (gal/min)	Flow from River		Flow from Injection Wells	
						%	Time (years)	%	Time (years)
100-HR-3									
Scenario 1-1	114-15A	10	100			17	0.5-1	11	5-6
	114-12A	10	50			11	0.5-1	89	4.5-5
	114-11	10	50			0	--	100	2
				114-48	30				
Scenario 1-2	114-15A	20	100			39	0.5-1	39	2-2.5
	114-12A	20	50			33	0.5-1	67	1.5
	114-11	20	50			5	0.5	95	1.5
				114-48	60				
Scenario 2-3	114-7	20	100			0	--	44	3-3.5
	New well	20	100			0	--	44	3
				New well	40				
Scenario 3-4	114-15A	10	100			39	0.5-1	0	--
	114-12A	10	50			39	0.5-1	61	3
	114-11	10	50			5	0.5-1	95	3.5-4
	114-7	20	100			0		67	2.5-3
				113-1	50				
Scenario 4-5	114-15A	10	100			11	0.5	89	5.5-6
	114-12A	10	50			0	--	100	2.5-3
	114-11	10	50			0	--	100	2.5
	114-7	20	100			0	--	100	2-2.5
				113-1	65				
				New well	65				
Scenario 4-6	114-15A	10	100			22	0.5	89	10+
	114-12A	10	50			22	0.5-1	100	4.5
	114-11	10	50			0	--	100	4.5
	114-7	10	100			0	--	100	4
				New well	65				
				New well	65				
Scenario 5-7 (Original Recommendation)	114-15A	10	100			50	0.5	50	14-15
	114-12A	10	50			44	0.5-1	56	4.5
	114-11	10	50			0	--	100	4.5
	114-7	20	100			0	--	100	3/8
	New well	40	100			0	--	100	2.5
				New well	85				
				New well	85				
Scenario 5-8	114-7	20	100			0	--	95	3.5/10+
	New well	40	100			0	--	100	2.5
				New well	65				
				New well	65				

Table B-1. Numerical Modeling Simulations. (sheet 2 of 2)

Operable Unit and Scenario	Extraction Wells	Purging Rate (gal/min)	Estimated Cr(VI) Conc. (µg/L)	Injection Well	Injection Rate (gal/min)	Flow from River		Flow from Injection Wells	
						%	Time (years)	%	Time (years)
Scenario B-1 (Recommended)	114-15A	10	100			28	0.5	72	11
	114-12A	10	50			11	0.5	89	4
	114-11	10	50			0	--	100	4
	114-7	20	100			0	--	100	2.5
	113-2A	40	120			0	--	100	1.5
				New well	85				
				New well	85				
Scenario B-2	114-7	20	100			0	--	100	2.5
	113-2A	40	120			0	--	100	1.5
				New well	65				
				New well	65				

Table B-2. Predicted Influent Chromium Concentration Values for Wells D8-53 and D8-54A Pumping at 151 L/min.

Time (years)	Chromium Concentration (μg/L)	
	Well D8-53	Well D8-54A
1	500	360
2	500	180
3	420	170
4	420	170
5	360	170

Table B-3. Summary of the Well Inventory List Used in the 100-K Area Modeled Scenarios.

Scenario	Extraction Wells	Injection Wells	Comments
1	K-120A K-118A K-116A K-115A K-113A	K-122A K-123A K-124A	
2	K-120A K-118A K-116A K-115A K-113A	K-122A K-123A K-124A	Well K-118A is moved approximately 70 m closer to well K-120A.
3	K-120A K-118A K-116A K-115A K-113A K-X1A	K-122A K-123A K-124A	Well K-X1A is located near the trench approximately half way between K-120A and K-118A.
4	K-120A K-118A K-116A K-115A K-113A K-X2A K-X3A	K-122A K-123A K-124A	Wells K-X2A and K-X3A are located near the trench and equally spaced between K-120A and K-118A.
5	K-120A K-118A K-116A K-115A K-113A	K-122A K-123A K-124A	The upgradient model boundary is constant flow instead of constant head.

Table B-4. Expected Concentration of Effluent Expressed as a Percentage of the Initial Concentration for 100-K Area Scenarios 1 and 2.

Time (years)	Number of Streampaths Originating at the River (per 12 per well)	Effluent Concentration (% of Initial)
1	0	100
2	1	98
3	6	90
4	9	85
5	10	83

Table B-5. Expected Concentration of Effluent Expressed as a Percentage of the Initial Concentration for 100-K Area Scenario 3.

Time (years)	Number of Streampaths Originating at the River (per 12 total per well)	Number of Streampaths Originating at the Injection Well Field (per 12 per well)	Effluent Concentration (% of Initial)
1	0	0	100
2	2	0	97
3	7	0	90
4	12	0	83
5	12	10	69

Table B-6. Expected Concentration of Effluent Expressed as a Percentage of the Initial Concentration for 100-K Area Scenario 4.

Time (years)	Number of Streampaths Originating at the River (per 12 total per well)	Number of Streampaths Originating at the Injection Well Field (per 12 per well)	Effluent Concentration (% of Initial)
1	0	0	100
2	2	0	98
3	9	0	89
4	13	0	85
5	15	20	58

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APPENDIX C

GROUNDWATER DATA TABLES

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APPENDIX C

GROUNDWATER DATA TABLES

C1.0 INTRODUCTION

The following tables present data that have been used to describe conceptual site models and for some aspects of design. Two groups of data have been compiled: (1) a summary of water quality and waste indicators in groundwater (Tables C-1, C-3, and C-5), and (2) a summary of water level and specific conductance data for wells. The two groups of data have been further divided into tables for each reactor area (Tables C-2, C-4, and C-6).

The data have been extracted from the Hanford Environmental Information System. Several processing steps have been applied to create common units and to correct known errors in reported results. However, there has been no attempt to identify outliers or nonrepresentative values. The data set covers the interval January 1, 1994 to August 30, 1995 and is considered to be representative of long-term average conditions.

C1.1 SUMMARY OF WASTE INDICATORS CONSTITUENTS IN GROUNDWATER

The wells selected for each area are those proposed as extraction wells, or wells located nearby the proposed extraction wells (Tables C-1, C-3, and C-5). A standard has been included to provide some measure of the signficance of the constituent concentration. Standards listed are generally the more restrictive of the various concentrations specified in numerous regulations (e.g., U.S. Environmental Protection Agency [EPA] drinking water standards, Washington State Water Quality Standard, and EPA Ambient Water Quality Criteria for aquatic organisms).

C1.2 WATER LEVEL AND SPECIFIC CONDUCTANCE VARIABILITY

Data for Tables C-2, C-4, and C-6 were extracted from the Hanford Environmental Information System in the form of depth-to-water measurements. These values were combined with recent top-of-casing surveys, using either U.S. Army Corps of Engineers results from an extensive 1993 survey, or recent ICF Kaiser Engineers Hanford, Inc. results, when Corps data are not available. These recent surveys are conducted to a common, revised set of baseline monuments, and use National Geodetic Vertical Datum of 1929 (NGVD29) as the vertical reference.

The difference between minimum and maximum water level elevations is presented in the Range column. Ranges provide a measure of the degree to which river stage fluctuations influence the

well. Wells have been arranged in order of increasing distance from the river shoreline, as defined during low river stage.

Values for specific conductance have been included in Tables C-2, C-4, and C-6. Specific conductance, which is determined by the amount of dissolved salts in the groundwater, can be a used to identify various water types. River water is typically in the range of 120 to 140 µS/cm. Groundwater from the Hanford gravels is approximately 400 µS/cm, while water from the Ringold Formation appears to be approximately 300 µS/cm, although data to support this are limited. Given these contrasts, specific conductance is thought to be useful in describing the interaction between river water and groundwater. Where contamination is present, specific conductance may vary over a wide range, thus reducing its usefulness as a indicator of natural water types.

Table C-1. Summary of Waste Indicator Constituents in 100-H Area Groundwater. (sheet 1 of 3)

CON_LONG_NAME	Units	Filtered	#Results	Standard	Average	Minimum	Maximum
Well 199-H3-2A							
Alkalinity	ppb	N	1	20,000	150,000	150,000	150,000
Chromium	ppb	N	5	11	89.40	32	160
Chromium	ppb	Y	6	11	51	16	110
Conductivity	umhos/cm	N	12	N/A	356.08	276	466
Dissolved Oxygen	mg/L	N	1	N/A	0.37	0.37	0.37
Gross alpha	pCi/L	N	6	15	2.19	0.949	3.64
Gross beta	pCi/L	N	6	50	6.38	5.07	8.38
Iron	ppb	Y	6	300	23.03	5.20	58
Manganese	ppb	Y	6	50	1.35	0.72	3
Nitrate	ppb	N	6	45,000	15,366.67	7,400	26,000
pH Measurement	pH	N	7	6.5 - 8.5	7.92	7.80	8.13
Strontium-90	pCi/L	N	1	8	0.03	0.0267	0.0267
Sulfate	ppb	N	6	250,000	39,833.33	26,000	63,000
Technetium-99	pCi/L	N	6	900	0.54	-0.668	3.58
Tritium	pCi/L	N	2	20,000	3,660	1,660	5,660
Uranium	ppb	N	6	59	2.37	0.786	3.94
Uranium-233/234	pCi/L	N	--	N/A	--	--	--
Uranium-235	pCi/L	N	--	N/A	--	--	--
Uranium-238	pCi/L	N	--	N/A	--	--	--
Well 199-H4-7							
Alkalinity	ppb	N	1	20,000	180,000	180,000	180,000
Chromium	ppb	N	4	11	111.25	95	130
Chromium	ppb	Y	6	11	86.83	77	92
Conductivity	umhos/cm	N	11	N/A	467.36	417	608
Dissolved Oxygen	mg/L	N	--	N/A	--	--	--
Gross alpha	pCi/L	N	6	15	2.96	0.372	5.14
Gross beta	pCi/L	N	6	50	6.14	3.75	8.26
Iron	ppb	Y	6	300	15.97	6.80	24
Manganese	ppb	Y	6	50	0.95	0.72	1.35
Nitrate	ppb	N	6	45,000	27,666.67	23,000	36,000
pH Measurement	pH	N	6	6.5 - 8.5	7.47	6.92	7.79
Strontium-90	pCi/L	N	--	8	--	--	--
Sulfate	ppb	N	6	250,000	62,500	52,000	88,000
Technetium-99	pCi/L	N	6	900	0.19	-0.666	1.04
Tritium	pCi/L	N	1	20,000	3,300	3,300	3,300
Uranium	ppb	N	6	59	3.98	2.77	6.69
Uranium-233/234	pCi/L	N	--	N/A	--	--	--
Uranium-235	pCi/L	N	--	N/A	--	--	--
Uranium-238	pCi/L	N	--	N/A	--	--	--

Table C-1. Summary of Waste Indicator Constituents in 100-H Area Groundwater. (sheet 2 of 3)

CON_LONG_NAME	Units	Filtered	#Results	Standard	Average	Minimum	Maximum
Well 199-H4-11							
Alkalinity	ppb	N	1	20,000	100,000	100,000	100,000
Chromium	ppb	N	7	11	60.71	40	91
Chromium	ppb	Y	9	11	52	40	75
Conductivity	umhos/cm	N	13	N/A	379.15	329	446
Dissolved Oxygen	mg/L	N	1	N/A	--	--	--
Gross alpha	pCi/L	N	7	15	2.96	1.77	4.34
Gross beta	pCi/L	N	7	50	50.51	36	72
Iron	ppb	Y	9	300	16	11	21
Manganese	ppb	Y	9	50	1.20	0.69	3
Nitrate	ppb	N	9	45,000	27,444.44	21,000	43,000
pH Measurement	pH	N	8	6.5 - 8.5	7.74	7.34	8.12
Strontium-90	pCi/L	N	4	8	16.65	14.30	18.20
Sulfate	ppb	N	9	250,000	42,888.89	32,000	65,000
Technetium-99	pCi/L	N	9	900	26.28	2.39	87.60
Tritium	pCi/L	N	4	20,000	934	7.91	1,040
Uranium	ppb	N	9	59	3.88	2.30	5.83
Uranium-233/234	pCi/L	N	--	N/A	--	--	--
Uranium-235	pCi/L	N	--	N/A	--	--	--
Uranium-238	pCi/L	N	--	N/A	--	--	--
Well 199-H4-12A							
Alkalinity	ppb	N	2	20,000	105,000	90,000	120,000
Chromium	ppb	N	6	11	71	26	99
Chromium	ppb	Y	7	11	71.71	28	96
Conductivity	umhos/cm	N	13	N/A	401.15	240	476
Dissolved Oxygen	mg/L	N	1	N/A	--	--	--
Gross alpha	pCi/L	N	6	15	3.09	0.193	4.55
Gross beta	pCi/L	N	6	50	14.82	2.40	28.30
Iron	ppb	Y	7	300	16.04	10	27
Manganese	ppb	Y	7	50	1.22	0.72	3
Nitrate	ppb	N	7	45,000	33,485.50	21,000	51,000
pH Measurement	pH	N	8	6.5 - 8.5	7.79	7.23	8.15
Strontium-90	pCi/L	N	1	8	0.30	0.295	0.295
Sulfate	ppb	N	7	250,000	42,714.29	20,000	53,000
Technetium-99	pCi/L	N	7	900	33.59	0.158	120
Tritium	pCi/L	N	3	20,000	1,953.33	1,180	2,400
Uranium	ppb	N	6	59	5.50	1.75	8.36
Uranium-233/234	pCi/L	N	--	N/A	--	--	--
Uranium-235	pCi/L	N	--	N/A	--	--	--
Uranium-238	pCi/L	N	--	N/A	--	--	--

Table C-1. Summary of Waste Indicator Constituents in 100-H Area Groundwater. (sheet 3 of 3)

CON_LONG_NAME	Units	Filtered	#Results	Standard	Average	Minimum	Maximum
Well 199-H4-12C							
Alkalinity	ppb	N	2	20,000	100,000	100,000	100,000
Chromium	ppb	N	7	11	355.29	277	650
Chromium	ppb	Y	8	11	281.25	270	290
Conductivity	umhos/cm	N	13	N/A	264.62	238	273
Dissolved Oxygen	mg/L	N	1	N/A	--	--	--
Gross alpha	pCi/L	N	7	15	1.05	0.401	1.91
Gross beta	pCi/L	N	7	50	4.16	2.15	6.09
Iron	ppb	Y	8	300	13.45	5.24	30
Manganese	ppb	Y	8	50	1.18	0.72	3
Nitrate	ppb	N	8	45,000	6,275	5,900	7,000
pH Measurement	pH	N	8	6.5 - 8.5	8	7.75	8.46
Strontium-90	pCi/L	N	1	8	-0.01	-0.0097	-0.0097
Sulfate	ppb	N	8	250,000	24,125	23,000	26,000
Technetium-99	pCi/L	N	8	900	0.16	-0.867	2.03
Tritium	pCi/L	N	3	20,000	59.80	-52.90	165
Uranium	ppb	N	7	59	1.50	1.18	1.70
Uranium-233/234	pCi/L	N	--	N/A	--	--	--
Uranium-235	pCi/L	N	--	N/A	--	--	--
Uranium-238	pCi/L	N	--	N/A	--	--	--
Well 199-H4-15A							
Alkalinity	ppb	N	1	20,000	110,000	110,000	110,000
Chromium	ppb	N	7	11	107.93	41	160
Chromium	ppb	Y	9	11	98.60	44.60	121
Conductivity	umhos/cm	N	12	N/A	406.83	339	625
Dissolved Oxygen	mg/L	N	1	N/A	8.20	8.20	8.20
Gross alpha	pCi/L	N	8	15	2.97	-0.133	16.10
Gross beta	pCi/L	N	8	50	6.08	3.58	9.74
Iron	ppb	Y	9	300	33.07	12	62.20
Manganese	ppb	Y	9	50	2.03	0.72	3.80
Nitrate	ppb	N	13	45,000	20,297.25	14,608.44	27,490.428
pH Measurement	pH	N	9	6.5 - 8.5	7.64	7	8.13
Strontium-90	pCi/L	N	4	8	0.19	0	0.355
Sulfate	ppb	N	9	250,000	40,133.33	30,900	47,000
Technetium-99	pCi/L	N	6	900	-0.23	-2.47	1.57
Tritium	pCi/L	N	5	20,000	2,154	1,920	2,450
Uranium	ppb	N	4	59	2.27	1.83	2.58
Uranium-233/234	pCi/L	N	--	N/A	--	--	--
Uranium-235	pCi/L	N	2	N/A	0.04	-0.0211	0.109
Uranium-238	pCi/L	N	2	N/A	0.70	0.343	1.06

Table C-2. Water Level and Specific Conductance Variability in 100-H Area Wells.

Well	Distance Inland (ft)	Water Level (ft)		Specific Conductance (uS/cm)	
		Average	Range	Average	Range
199-H4-4	400	373.98	6.2	666	854
199-H4-10	410	374.62	4.8	262	140
199-H4-11	420	373.95	5.7	375	117
199-H4-12A	440	374.31	4.9	410	236
199-H4-12B	440	374.38	4.9	407	151
199-H4-15A	460	374.48	4.8	407	286
199-H4-15B	460	374.53	4.7	337	45
199-H4-13	500	373.63	5.9	306	129
199-H49-5	560	374.34	4.2	485	44
199-H4-18	710	374.59	2.8	426	194
199-H-9	720	374.46	5.3	521	267
199-H4-3	730	374.53	5.5	1,132	992
199-H4-17	810	374.77	3.1	515	42
199-H4-8	810	374.91	4.6	489	46
199-H4-45	960	374.04	1.9	313	179
199-H4-7	1,050	375.02	2.2	467	191
199-H6-1	1,100	374.16	2.0	417	79
199-H4-16	1,120	374.94	1.7	308	131
199-H4-14	1,300	375.48	1.6	442	430
199-H4-47	1,430	375.28	1.4	286	196
199-H4-48	1,610	375.52	1.5	260	163
199-H4-6	1,610	375.60	2.1	459	215
199-H4-46	1,710	375.09	1.5	413	130
199-H3-2A	1,780	375.69	1.5	346	190
199-H3-2B	1,780	375.63	1.5	389	177
199-H4-49	2,110	375.96	1.1	383	327
199-H3-1	2,300	375.91	1.6	331	173
199-H5-1A	2,660	375.95	1.0	609	287
699-97-43	2,660	378.38	0.5	378	22
699-96-43	3,990	378.83	0.4	389	59
199-H4-12C	99,430	374.13	5.1	265	35
199-H4-15CR	99,460	374.12	2.2	--	--
199-H4-2C	991,780	375.65	1.5	248	187

NOTES: Wells are listed in order of increasing distance from the river shoreline during low river stage conditions. Wells not representative of water-table conditions (e.g., H4-12C) have a "99___" prefix added to their distance inland. Data are representative of conditions 01/01/94 through 08/30/95.

Table C-3. Summary of Waste Indicator Constituents in 100-D/DR Area Wells. (sheet 1 of 3)

CON_LONG_NAME	Units	Filtered	#Results	Standard	Average	Minimum	Maximum
Well 199-D8-3							
Alkalinity	ppb	N	--	20,000	--	--	--
Chromium	ppb	N	6	11	140.57	98.40	170
Chromium	ppb	Y	7	11	132.29	81	158
Conductivity	umhos/cm	N	6	N/A	726.83	654	845
Dissolved Oxygen	mg/L	N	1	N/A	4.65	4.65	4.65
Gross alpha	pCi/L	N	6	15	2.53	1.40	3.72
Gross beta	pCi/L	N	7	50	14.20	11.30	18
Iron	ppb	Y	7	300	21.80	11.60	40.30
Manganese	ppb	Y	7	50	3.27	1.30	7.20
Nitrate	ppb	N	13	45,000	167,960.79	147,412.44	201,419.40
pH Measurement	pH	N	5	6.5 - 8.5	9.45	9.08	10.08
Strontium-90	pCi/L	N	7	8	3.55	2.77	4.57
Sulfate	ppb	N	7	250,000	127,428.57	120,000	136,000
Technetium-99	pCi/L	N	--	900	--	--	--
Tritium	pCi/L	N	7	20,000	3,231.43	1,860	3,970
Uranium	ppb	N	1	59	1.92	1.92	1.92
Uranium-233/234	pCi/L	N	--	N/A	--	--	--
Uranium-235	pCi/L	N	--	N/A	--	--	--
Uranium-238	pCi/L	N	--	N/A	--	--	--
Well 199-D8-53							
Alkalinity	ppb	N	--	20,000	--	--	--
Chromium	ppb	N	5	11	346.20	269	391
Chromium	ppb	Y	5	11	337.60	271	368
Conductivity	umhos/cm	N	4	N/A	554.75	494	609
Dissolved Oxygen	mg/L	N	--	N/A	--	--	--
Gross alpha	pCi/L	N	4	15	2.09	1.72	2.89
Gross beta	pCi/L	N	4	50	15.53	13.80	17.10
Iron	ppb	Y	5	300	22.28	9.60	35.10
Manganese	ppb	Y	5	50	3.24	0.90	5.40
Nitrate	ppb	N	10	45,000	50,479.22	33,510.876	65,073.96
pH Measurement	pH	N	5	6.5 - 8.5	7.59	7.05	8.01
Strontium-90	pCi/L	N	4	8	6.09	5.50	7.36
Sulfate	ppb	N	5	250,000	100,680	76,000	123,000
Technetium-99	pCi/L	N	--	900	--	--	--
Tritium	pCi/L	N	4	20,000	10,690	8,160	12,000
Uranium	ppb	N	--	59	--	--	--
Uranium-233/234	pCi/L	N	--	N/A	--	--	--
Uranium-235	pCi/L	N	--	N/A	--	--	--
Uranium-238	pCi/L	N	--	N/A	--	--	--

Table C-3. Summary of Waste Indicator Constituents in 100-D/DR Area Wells. (sheet 2 of 3)

CON_LONG_NAME	Units	Filtered	#Results	Standard	Average	Minimum	Maximum
Well 199-D8-54A							
Alkalinity	ppb	N	1	20,000	90,000	90,000	90,000
Chromium	ppb	N	5	11	441.80	327	538
Chromium	ppb	Y	6	11	420.17	310	480
Conductivity	umhos/cm	N	6	N/A	590.67	457	647
Dissolved Oxygen	mg/L	N	--	N/A	--	--	--
Gross alpha	pCi/L	N	4	15	1.99	1.05	3.06
Gross beta	pCi/L	N	4	50	17.88	14.20	21
Iron	ppb	Y	6	300	31.98	13.40	50.30
Manganese	ppb	Y	6	50	3	1.50	4.90
Nitrate	ppb	N	10	45,000	51,076.84	34,351.968	69,058.08
pH Measurement	pH	N	5	6.5 - 8.5	7.85	7.31	8.15
Strontium-90	pCi/L	N	6	8	6.43	5.38	7.12
Sulfate	ppb	N	6	250,000	106,800	79,300	128,000
Technetium-99	pCi/L	N	--	900	--	--	--
Tritium	pCi/L	N	6	20,000	14,740	9,240	18,000
Uranium	ppb	N	2	59	2.84	2.76	2.91
Uranium-233/234	pCi/L	N	--	N/A	--	--	--
Uranium-235	pCi/L	N	--	N/A	--	--	--
Uranium-238	pCi/L	N	--	N/A	--	--	--
Well 199-D8-54B							
Alkalinity	ppb	N	1	20,000	170,000	170,000	170,000
Chromium	ppb	N	5	11	51.36	28.20	77
Chromium	ppb	Y	5	11	7.56	5.60	9.20
Conductivity	umhos/cm	N	5	N/A	457.20	413	475
Dissolved Oxygen	mg/L	N	1	N/A	8.10	8.10	8.10
Gross alpha	pCi/L	N	4	15	3.39	1.73	5.48
Gross beta	pCi/L	N	4	50	9.86	7.04	12.30
Iron	ppb	Y	5	300	38.38	22	48
Manganese	ppb	Y	5	50	103.12	65	145
Nitrate	ppb	N	9	45,000	1,962.07	1,700	2,257.668
pH Measurement	pH	N	5	6.5 - 8.5	7.77	7.50	7.96
Strontium-90	pCi/L	N	5	8	-0.02	-0.24	0.383
Sulfate	ppb	N	5	250,000	64,200	61,500	67,400
Technetium-99	pCi/L	N	--	900	--	--	--
Tritium	pCi/L	N	5	20,000	-8.56	-112	130
Uranium	ppb	N	1	59	2.34	2.34	2.34
Uranium-233/234	pCi/L	N	--	N/A	--	--	--
Uranium-235	pCi/L	N	--	N/A	--	--	--
Uranium-238	pCi/L	N	--	N/A	--	--	--

Table C-3. Summary of Waste Indicator Constituents in 100-D/DR Area Wells. (sheet 3 of 3)

CON_LONG_NAME	Units	Filtered	#Results	Standard	Average	Minimum	Maximum
Well 199-D8-55							
Alkalinity	ppb	N	--	20,000	--	--	--
Chromium	ppb	N	4	11	74.33	42.40	121
Chromium	ppb	Y	4	11	15.45	11.20	21.30
Conductivity	umhos/cm	N	3	N/A	271	226	331
Dissolved Oxygen	mg/L	N	1	N/A	6.50	6.50	6.50
Gross alpha	pCi/L	N	4	15	0.72	0.364	1.25
Gross beta	pCi/L	N	4	50	4.13	3.20	4.65
Iron	ppb	Y	4	300	39.78	13.40	84.20
Manganese	ppb	Y	4	50	3.50	1.60	5.20
Nitrate	ppb	N	8	45,000	7,874.17	6,197.52	9,207.744
pH Measurement	pH	N	4	6.5 - 8.5	7.87	7.06	8.19
Strontium-90	pCi/L	N	4	8	0.01	-0.055	0.104
Sulfate	ppb	N	4	250,000	29,425	26,000	31,000
Technetium-99	pCi/L	N	--	900	--	--	--
Tritium	pCi/L	N	4	20,000	98.40	40.60	128
Uranium	ppb	N	--	59	--	--	--
Uranium-233/234	pCi/L	N	--	N/A	--	--	--
Uranium-235	pCi/L	N	--	N/A	--	--	--
Uranium-238	pCi/L	N	--	N/A	--	--	--

Table C-4. Water Level and Specific Conductance Variability in 100-D/DR Area Wells.

Well	Distance Inland (ft)	Water Level (ft)		Specific Conductance (uS/cm)	
		Average	Range	Average	Range
699-101-48B	320	379.67	5.4	--	--
199-D8-55	390	381.59	5.1	271	105
199-D8-5	500	382.30	3.9	215	26
199-D5-20	600	382.94	3.3	393	73
199-D8-54A	600	381.58	5.0	591	190
199-D8-53	700	381.55	5.0	555	115
199-D8-4	760	383.07	3.2	133	37
199-D8-6	860	383.02	3.6	142	27
199-D8-3	1,090	381.46	4.1	727	191
199-D5-13	1,300	383.32	2.0	492	190
699-97-51A	1,650	381.09	2.0	412	19
199-D2-6	2,100	384.20	2.1	608	193
199-D5-14	2,200	383.88	0.7	567	270
199-D5-15	2,410	384.17	0.9	553	154
199-D5-16	2,790	383.80	0.6	552	72
199-D5-12	2,940	383.79	2.8	874	121
699-96-49	3,080	381.40	5.3	383	134
199-D5-17	3,360	384.49	0.9	450	213
199-D5-18	3,670	384.32	0.6	665	76
199-D5-19	3,800	384.63	0.5	678	103
199-D2-5	3,950	384.70	0.8	534	62
199-D8-54B	99,600	382.22	7.8	457	62

NOTES: Wells are listed in order of increasing distance from the river shoreline during low river stage conditions. Wells not representative of water-table conditions (e.g., H4-54B) have a "99___" prefix added to their distance inland. Data are representative of conditions 01/01/94 through 08/30/95.

Table C-5. Summary of Waste Indicator Constituents in 100-K Area Groundwater. (sheet 1 of 3)

CON_LONG_NAME	Units	Filtered	#Results	Standard	Average	Minimum	Maximum
Well 199-K-18							
Alkalinity	ppb	N	--	20,000	--	--	--
Chromium	ppb	N	4	11	41.88	35.70	47.70
Chromium	ppb	Y	5	11	33.34	27.20	38
Conductivity	umhos/cm	N	16	N/A	459.51	5.20	670
Dissolved Oxygen	mg/L	N	1	N/A	5.03	503	503
Gross alpha	pCi/L	N	4	15	0.22	-0.16	0.888
Gross beta	pCi/L	N	5	50	4.65	2.20	6.40
Iron	ppb	Y	5	300	51.72	15	101
Manganese	ppb	Y	5	50	7.68	5.30	10.90
Nitrate	ppb	N	8	45,000	98,464.83	93,000	105,357.84
pH Measurement	pH	N	14	6.5 - 8.5	8.09	7.06	8.28
Strontium-90	pCi/L	N	5	8	0.39	-0.16	1.90
Sulfate	ppb	N	8	250,000	66,112.50	62,000	70,500
Technetium-99	pCi/L	N	1	900	1.22	1.22	1.22
Tritium	pCi/L	N	21	20,000	15,271.43	11,000	21,200
Uranium	ppb	N	--	59	--	--	--
Uranium-233/234	pCi/L	N	--	N/A	--	--	--
Uranium-235	pCi/L	N	4	N/A	0.06	-0.00443	0.215
Uranium-238	pCi/L	N	4	N/A	0.17	0.0797	0.27
Well 199-K-19							
Alkalinity	ppb	N	--	20,000	--	--	--
Chromium	ppb	N	5	11	116.34	92.70	136
Chromium	ppb	Y	8	11	110.08	90.70	130
Conductivity	umhos/cm	N	11	N/A	343.18	290	403
Dissolved Oxygen	mg/L	N	1	N/A	6.38	6.38	6.38
Gross alpha	pCi/L	N	8	15	0.78	0.039	2.30
Gross beta	pCi/L	N	8	50	26.15	20.10	33
Iron	ppb	Y	8	300	28.71	9.3	80.60
Manganese	ppb	Y	8	50	2.37	1	3.5
Nitrate	ppb	N	5	45,000	28,022.51	20,000	39,088.644
pH Measurement	pH	N	8	6.5 - 8.5	8.16	7.73	8.67
Strontium-90	pCi/L	N	5	8	11.38	9.30	13.10
Sulfate	ppb	N	5	250,000	51,740	50,000	52,900
Technetium-99	pCi/L	N	--	900	--	--	--
Tritium	pCi/L	N	8	20,000	4,167.50	2,500	5,500
Uranium	ppb	N	--	59	--	--	--
Uranium-233/234	pCi/L	N	--	N/A	--	--	--
Uranium-235	pCi/L	N	5	N/A	0.03	-0.0163	0.0636
Uranium-238	pCi/L	N	5	N/A	0.34	0.169	0.661

Table C-5. Summary of Waste Indicator Constituents in 100-K Area Groundwater. (sheet 2 of 3)

CON_LONG_NAME	Units	Filtered	#Results	Standard	Average	Minimum	Maximum
Well 199-K-20							
Alkalinity	ppb	N	--	20,000	--	--	--
Chromium	ppb	N	4	11	160.50	154	168
Chromium	ppb	Y	4	11	154.25	145	170
Conductivity	umhos/cm	N	5	N/A	321.40	307	334
Dissolved Oxygen	mg/L	N	1	N/A	7.35	7.35	7.35
Gross alpha	pCi/L	N	4	15	1.09	0.176	2.04
Gross beta	pCi/L	N	4	50	27.63	19.30	32.70
Iron	ppb	Y	4	300	47.40	12.90	118
Manganese	ppb	Y	4	50	2.50	1.80	3
Nitrate	ppb	N	2	45,000	20,606.75	14,874.048	26,339.46
pH Measurement	pH	N	5	6.5 - 8.5	8.14	7.95	8.26
Strontium-90	pCi/L	N	4	8	10.19	9.02	12.70
Sulfate	ppb	N	2	250,000	52,650	49,700	55,600
Technetium-99	pCi/L	N	--	900	--	--	--
Tritium	pCi/L	N	4	20,000	522.50	488	590
Uranium	ppb	N	--	59	--	--	--
Uranium-233/234	pCi/L	N	--	N/A	--	--	--
Uranium-235	pCi/L	N	4	N/A	0.10	0.029	0.172
Uranium-238	pCi/L	N	4	N/A	0.59	0.199	1.01
Well 199-K-21							
Alkalinity	ppb	N	--	20,000	--	--	--
Chromium	ppb	N	4	11	106.80	94	131
Chromium	ppb	Y	4	11	80.78	65.40	90
Conductivity	umhos/cm	N	5	N/A	333.60	299	416
Dissolved Oxygen	mg/L	N	2	N/A	6.10	6.10	6.10
Gross alpha	pCi/L	N	4	15	1.06	0.39	1.35
Gross beta	pCi/L	N	4	50	65	56.20	89
Iron	ppb	Y	4	300	27.88	12.30	47.10
Manganese	ppb	Y	4	50	3.25	2.90	3.90
Nitrate	ppb	N	3	45,000	15,072.29	13,280.40	16,000
pH Measurement	pH	N	5	6.5 - 8.5	8.18	7.83	8.53
Strontium-90	pCi/L	N	4	8	28.53	27.40	30.30
Sulfate	ppb	N	3	250,000	55,000	54,200	55,800
Technetium-99	pCi/L	N	--	900	--	--	--
Tritium	pCi/L	N	5	20,000	759.80	640	864
Uranium	ppb	N	--	59	--	--	--
Uranium-233/234	pCi/L	N	--	N/A	--	--	--
Uranium-235	pCi/L	N	4	N/A	0.12	-0.00921	0.441
Uranium-238	pCi/L	N	4	N/A	0.31	0.156	0.505

Table C-5. Summary of Waste Indicator Constituents in 100-K Area Groundwater. (sheet 3 of 3)

CON_LONG_NAME	Units	Filtered	#Results	Standard	Average	Minimum	Maximum
Well 199-K-22							
Alkalinity	ppb	N	--	20,000	--	--	--
Chromium	ppb	N	4	11	156.25	148	162
Chromium	ppb	Y	4	11	149.25	131	160
Conductivity	umhos/cm	N	5	N/A	321.20	268	446
Dissolved Oxygen	mg/L	N	1	N/A	8.25	8.25	8.25
Gross alpha	pCi/L	N	4	15	1.06	0.375	1.50
Gross beta	pCi/L	N	4	50	15.05	12.30	21.40
Iron	ppb	Y	4	300	37.88	9.30	77.30
Manganese	ppb	Y	4	50	5.05	1.90	9.90
Nitrate	ppb	N	2	45,000	14,298.56	13,280.40	15,316.728
pH Measurement	pH	N	5	6.5 - 8.5	7.76	7.08	8.03
Strontium-90	pCi/L	N	3	8	5.11	2.60	7.31
Sulfate	ppb	N	2	250,000	49,650	49,400	49,900
Technetium-99	pCi/L	N	--	900	--	--	--
Tritium	pCi/L	N	4	20,000	408.50	308	557
Uranium	ppb	N	--	59	--	--	--
Uranium-233/234	pCi/L	N	--	N/A	--	--	--
Uranium-235	pCi/L	N	4	N/A	0.03	0.0063	0.0522
Uranium-238	pCi/L	N	4	N/A	0.45	0.23	0.622
Well 199-K-37							
Alkalinity	ppb	N	--	20,000	--	--	--
Chromium	ppb	N	6	11	110	106	115
Chromium	ppb	Y	6	11	106.33	103	111
Conductivity	umhos/cm	N	4	N/A	268.75	243	282
Dissolved Oxygen	mg/L	N	1	N/A	7.89	7.89	7.89
Gross alpha	pCi/L	N	6	15	1.65	0.54	2.90
Gross beta	pCi/L	N	6	50	16.73	6.60	22
Iron	ppb	Y	6	300	28.97	7	89.10
Manganese	ppb	Y	6	50	2.73	1.20	4.10
Nitrate	ppb	N	2	45,000	5,843.38	5,577.768	6,108.984
pH Measurement	pH	N	4	6.5 - 8.5	8.16	8.01	8.32
Strontium-90	pCi/L	N	5	8	5.93	4.50	6.6
Sulfate	ppb	N	2	250,000	36,600	34,900	38,300
Technetium-99	pCi/L	N	--	900	--	--	--
Tritium	pCi/L	N	6	20,000	154.49	0.027	320
Uranium	ppb	N	--	59	--	--	--
Uranium-233/234	pCi/L	N	1	N/A	0.79	0.79	0.79
Uranium-235	pCi/L	N	6	N/A	0.01	-0.0394	0.048
Uranium-238	pCi/L	N	6	N/A	0.72	0.43	0.948

Table C-6. Water Level and Specific Conductance Variability in 100-K Area Wells.

Well	Distance Inland (ft)	Water Level (ft)		Specific Conductance (uS/cm)	
		Average	Range	Average	Range
199-K-31	350	386.25	6.7	297	51
199-K-20	560	386.35	4.3	321	27
199-K-21	700	385.57	3.7	334	117
199-K-33	800	386.66	5.9	596	170
199-K-18	840	386.54	3.7	490	359
199-K-32A	900	388.55	7.3	290	284
199-K-22	1,060	385.82	3.1	321	178
199-K-19	1,100	387.30	3.5	343	113
199-K-37	1,150	386.68	2.4	269	39
199-K-107A	1,350	390.52	3.4	330	59
199-K-34	1,390	390.25	3.5	433	76
199-K-106A	1,580	391.11	7.0	630	496
199-K-110A	1,660	393.29	2.3	437	707
199-K-13	1,680	391.11	2.3	291	121
199-K-109A	1,770	391.92	2.1	324	322
199-K-11	1,780	390.95	2.4	347	54
199-K-27	1,800	392.34	3.1	421	174
199-K-28	1,810	391.96	4.4	780	268
199-K-108A	1,820	392.10	4.6	443	111
199-K-29	1,850	392.46	4.1	321	119
199-K-23	1,890	392.68	1.9	606	234
199-K-30	1,910	392.67	2.6	506	188
199-K-111A	2,160	391.40	4.9	364	284
199-K-73	2,343	395.70	1.4	319	44
199-K-35	2,820	394.99	1.1	330	85
199-K-36	3,100	395.51	1.3	513	469
199-K-62	5,220	393.57	0.8	364	52
199-K-68	6,660	397.67	0.7	324	183
199-K-61	9,310	397.57	0.6	344	146
199-K-32B	99,900	396.77	2.2	387	93

NOTES: Wells are listed in order of increasing distance from the river shoreline during low river stage conditions. Wells not representative of water-table conditions (e.g., H4-32B) have a "99___" prefix added to their distance inland. Data are representative of conditions 01/01/94 through 08/30/95.

APPENDIX D

WASTE MANAGEMENT

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APPENDIX D

WASTE MANAGEMENT

D1.0 INTRODUCTION

The waste associated with the 100-HR-3 and 100-KR-4 interim action is defined as remediation waste and includes the following waste types:

- Drill cuttings (both dry and saturated), spent resin, filtered solids, and miscellaneous waste (e.g., contaminated pumps and filters) that will be generated during the interim action
- Purgewater generated during the construction, development, and monitoring of wells
- Water from slurry-pumping resins and gravity-draining resins.

In addition, waste defined as investigation-derived waste was previously generated during environmental investigations, treatability tests, and technology demonstrations. It includes the following waste types:

- Drums of potentially contaminated drill cuttings (both dry and saturated), resin, liquid waste, and miscellaneous waste generated during environmental investigations and the 100-HR-3 treatability test operations
- Unused volumes of soil and groundwater samples collected during investigations and returned by the laboratory.

Similar types of investigation-derived waste and remediation waste will be managed in the same manner. Management and disposal of the waste types are described in the following sections. In general, solid waste streams will be disposed at the Environmental Restoration Disposal Facility (ERDF) if they meet ERDF waste acceptance criteria or can be treated to meet the criteria. Key criteria are the chromium land disposal restriction (LDR) requirement of Toxic Characteristic Leaching Procedure (TCLP) of 5 mg/kg and the absence of free liquids. Liquid waste streams will be processed at the 100-HR-3 and 100-KR-4 treatment system if it is technically feasible to do so.

In the event that some material cannot be disposed of at the ERDF or other onsite facilities and disposal at an offsite facility is required, such a facility must be in compliance with the U.S. Environmental Protection Agency's (EPA) Offsite Rule (40 CFR 300.440) concerning offsite disposal of wastes.

D1.1 FILTERED SOLIDS

The treatment system is designed with inline filters to collect fine particulates from the treatment stream. Fine particles collect on filters located in filter housings. The filter elements will be removed from the filter housing and replaced when prescribed differential pressures are reached. These filters will be disposed per the requirements specified in a waste management plan for system operations.

D1.2 SPENT ION-EXCHANGE RESIN

Spent resin will be sampled to determine whether it meets the ERDF waste acceptance criteria for chromium. Resins will be sampled to characterize the waste prior to shipment for disposal. Once a trend is established, sampling requirements may be reduced. If the resins meet ERDF waste acceptance criteria, the resin will be disposed onsite at the ERDF. If the spent resin does not meet the ERDF waste acceptance criteria, a disposal option will be determined following a technical evaluation of various options and a cost-benefit analysis.

D1.3 DRILL CUTTINGS AND ASSOCIATED WASTE

Drill cuttings and other solid wastes (e.g., soil samples, pumps, contaminated tools) have been or will be generated to support 100-HR-3 and 100-KR-4 investigations, treatability tests, technology demonstrations, and remedial actions. The drill cuttings and contaminated solid wastes will be disposed of at the ERDF. This waste will be managed in accordance with respective waste management plans. The waste management plans for 100-HR-3 and 100-KR-4 drilling activities are included as attachments to this appendix.

Drill cuttings and other contaminated solid waste will be treated as necessary before disposal to ensure that they meet ERDF waste acceptance criterion prohibiting free liquids. It is expected that treatment of saturated cuttings will require decanting water from the soils, evaporation by removing the lids to drums, and/or the addition of sorbent material to the soils, to meet the ERDF criterion prohibiting free liquids.

D1.4 NONREGULATED REMEDIATION-DERIVED WASTES

All nonregulated remediation-derived wastes will be managed in accordance with their respective waste management plans. Examples of nonregulated wastes include gloves, tape, sampling equipment, and paper. All nonregulated remediation-derived waste will be disposed of in accordance with BHI waste management procedures.

D1.5 LIQUID WASTES

Contaminated water might be generated if saturated soils are decanted. In addition, purgewater will be generated during well installation, development, testing, and monitoring. An environmentally protective method of disposing of any decanted water or purgewater would be to process it through the 100-HR-3 or 100-KR-4 treatment system. Purgewater will be processed at the 100-HR-3 or 100-KR-4 treatment system if technically feasible. If not technically feasible, purgewater will continue to be managed at the Hanford Site purgewater tanks.

ATTACHMENT

100-HR-3 DRILLING WASTE MANAGEMENT PLAN

9713506.2019

DOE/RL-96-84
Rev. 0

DOE/RL-96-58
Rev. 0

100-HR-3 Operable Unit Drilling Waste Management Plan

Date Published
June 1996

United States
Department of Energy
P.O. Box 550
Richland, Washington 99352

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1.0 INTRODUCTION

This waste management plan (WMP) provides guidance for the management of waste generated as a result of groundwater well installations in the 100-HR-3 Operable Unit (OU). The well installations are necessary to implement the Interim Remedial Measure (IRM) option (pump-and-treat using ion exchange) to prevent discharge of hexavalent chromium at levels above those considered protective of aquatic life in the Columbia River and riverbed sediments. This document will be superceded by the Remedial Design/Remedial Action Work Plan.

2.0 DESCRIPTION

A total of nine wells are currently scheduled for installation in the 100-HR-3 OU in support of the IRM. Five wells will be drilled in the 100-H area (see Attachment 1). Three of these will be injection wells. The remaining two wells will be utilized as monitoring and/or extraction wells. Four wells will be drilled in the 100-D area (see Attachment 2). Three of these may be extraction wells and all will function as monitoring wells.

3.0 CONTAMINATION / FIELD SCREENING

Soil contamination is not anticipated during borehole advancement. Based upon existing groundwater monitoring data, there are no radiological contaminants expected in the soils, nor are there any non-radiological contaminants expected with the potential exception of chromium. As a precautionary measure, soil piles will be surveyed for radioactivity a minimum of once each day soils are added to the pile. Measurements will be made by a Radiological Control Technician (RCT) using hand-held screening instruments. Moist soil (i.e., soil generated from the aquifer) samples will be periodically tested for hexavalent chromium by Hach kit analysis.

Filtered groundwater will be tested for contaminants when the wells first reach the water table. Samples will be analyzed for hexavalent chromium, nitrate and sulfate by Hach kit to verify contamination levels. The groundwater generated during well drilling that exceeds release criteria (i.e., 80 ug/L hexavalent chromium, 45,000 ug/L nitrate and 250,000 ug/L sulfate) will be stored for future treatment in the 100-HR-3 IRM pump-and-treat system. Based on these analyses, groundwater will either be contained or disposed of on the ground surface.

Because a substantial quantity of historical analytical data exist for locales where the wells will be installed, formal laboratory soil or groundwater analyses for chemical and radiological

characterization will not be performed during the drilling activity. Soils are not anticipated to contain concentrations of chromium that will exceed the toxic characteristic leach procedure levels for hazardous/dangerous waste designation (5 ppm). The clean criteria for total chromium in soils is 18.5 mg/kg (ppm) based upon Hanford Site background values and is 8 mg/kg for hexavalent chromium based upon groundwater protection. No other groundwater constituents have been identified that would result in designation of the soils as radioactive, characteristic, or listed dangerous waste.

5.0 CONTAINMENT

Dry (vadose zone) spoils will be accumulated in piles near the point of generation. If the moist soils must be contained, the soils will be placed on plastic to prevent any residual, free groundwater from being released to the soil as an attempt to prepare soils to meet applicable waste acceptance or disposal criteria. Groundwater draining from spoil piles will be contained as described below.

Contaminated groundwater, above release limits, that is generated during well drilling will be contained in a portable tank and will subsequently be transferred to the approved storage containers described below.

Containment of decontamination rinsate will not be required, providing that downhole tools and equipment are wiped down to remove residual material prior to steam cleaning. The wiping must be sufficient to remove any solid contaminants that could conceivably show up in the rinsate. The subsequent steam cleaning will use potable water only (with no additives).

Groundwater or contaminated soil will be contained, when required, in steel 55-gal open head drums. Drums are to be no more than eighty percent (80%) full. The following information is to be written on the lid with indelible contrasting ink and maintained in legible condition until the Interim Control (IC) form is attached to the container:

- Project name
- Borehole number
- Footage (enter footage intervals)
- Contents (enter contents of container)
- Date sealed
- Unique container number (obtained from Environmental Restoration Waste Management [ERWM]).

The unique container number will be maintained in legible condition on the container lid from initial sealing of the container through disposal of the container contents. Unique container number legibility will be assessed during routine waste storage site inspection and maintained as required.

After making a copy, secure the completed plastic Interim Control (IC) Form (see Attachment 3) to the side of the container. The IC Form is filled out by the Field Engineer and, when completed, provides pertinent container specific information. Send the copy of the completed IC Form to ERWM for inventory tracking purposes.

Containers of groundwater or contaminated soil/slurry may be staged in temporary well-specific storage locales, near the point of generation, during active drilling operations. Containers will be elevated on pallets within storage areas. Following active drilling operations, containers will be consolidated into a single storage site established near the 100-HR-3 Pilot Scale Pump and Treat Site (see Attachment 4). Containers with free liquid (i.e., groundwater or saturated soils) to be stored outside during cold (freezing) weather will be overpacked (preferably in 95-gal reusable poly overpacks). The unique container number of the drum will be displayed on the overpack for container identification purposes. Containers will be routinely inspected along with other previously generated 100-HR-3 OU past practices waste.

6.0 DISPOSITION OF WASTE

Groundwater should be the only waste generated requiring extended management. All groundwater that is contained will be processed at a future date through the 100-HR-3 IRM pump-and-treat system. Uncontaminated soil piles will be leveled following well installation.

Contaminated soils will be contained and packaged as required to meet the Environmental Restoration Disposal Facility (ERDF) Waste Acceptance Criteria (WAC). This may require more handling than the simple dewatering technique applied above to meet ERDF WAC. Any water generated during waste preparation will be processed through the 100-HR-3 IRM pump-and-treat system. The remaining solids may be disposed to ERDF with other 100-HR-3 Operable Unit waste identified in the 100-HR-3 and 100-KR-4 Operable Units Record of Decision.

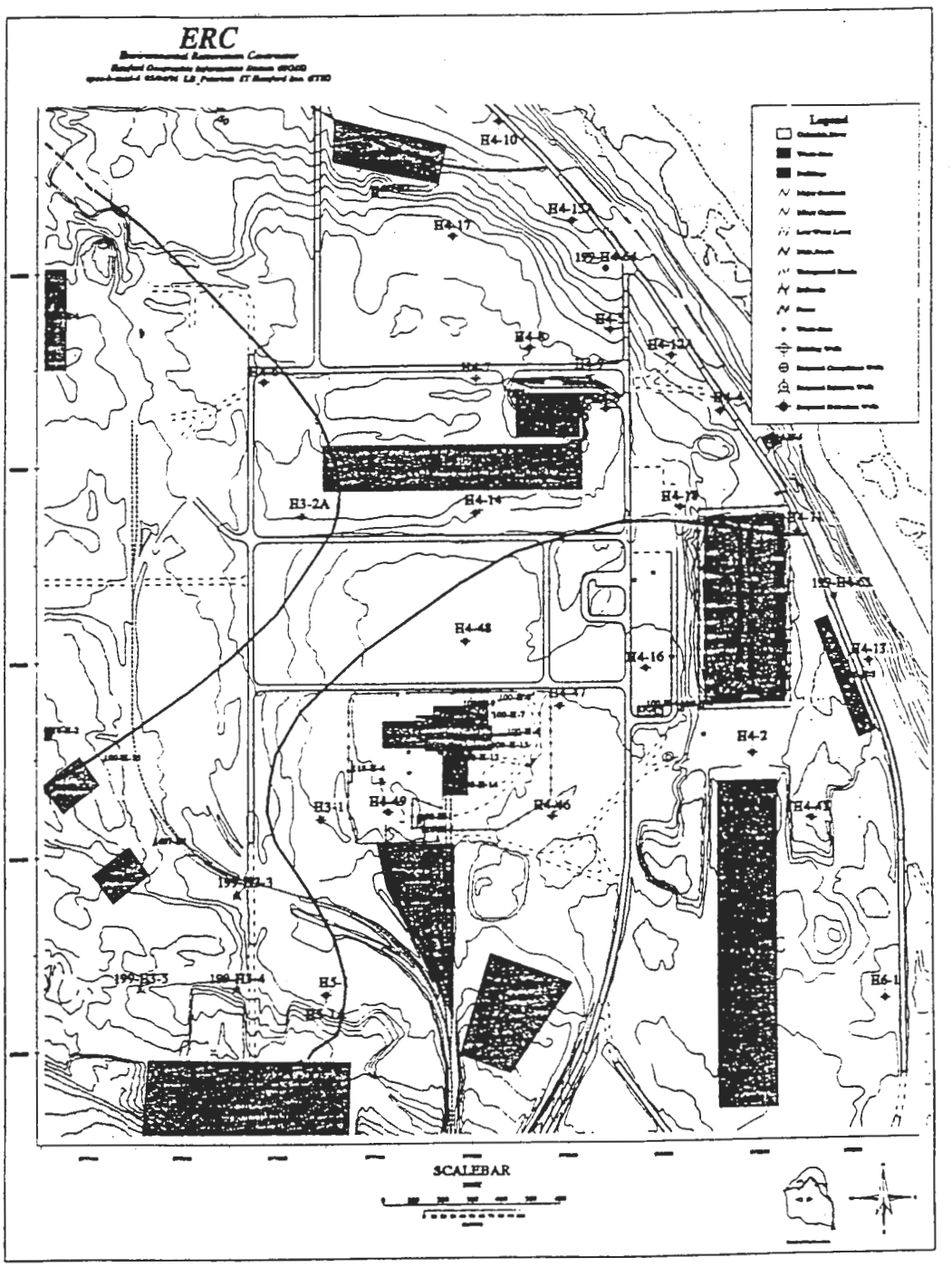
Purgewater shall be managed in accordance with BHI-EE-01, Volume 1, *Environmental Investigations Procedures (EIP)* 1.1, "Purge Water Management."

Miscellaneous trash items (e.g., rags, wipes, disposable personal protective equipment, etc.) will be nonregulated and disposed as such. Should radiological or chemical contamination be encountered then regulated trash would be contained and disposed appropriately; however, this situation is not expected.

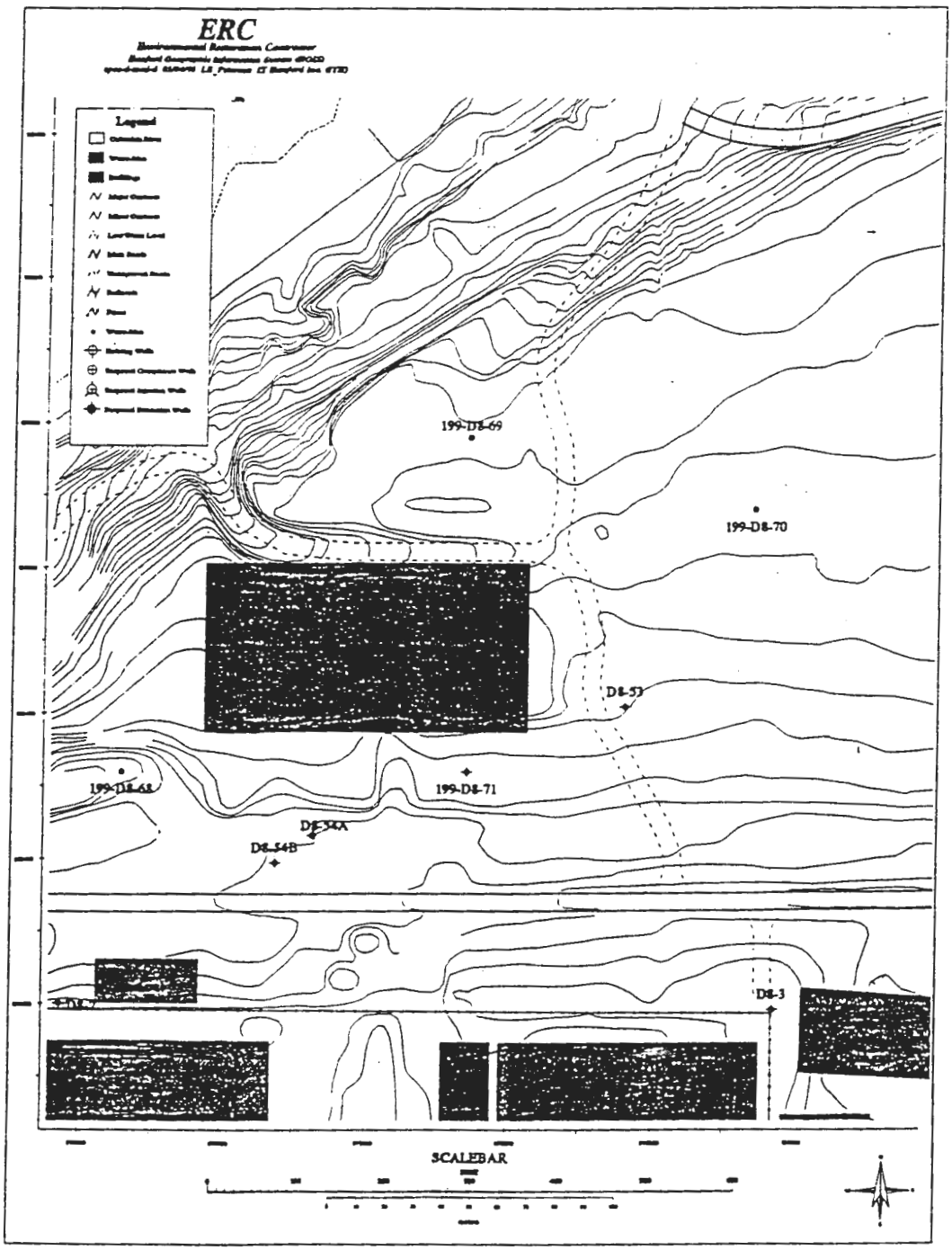
7.0 REFERENCES

BHI, 1996, *Environmental Investigations Procedures (EIP)* 1.1, "Purge Water Management," BHI-EE-01, Volume 1, Bechtel Hanford, Inc., Richland, Washington.

Attachment 1. 100-H Area Estimated New Well Locations.



Attachment 2. 100-D Area Estimated New Well Locations.



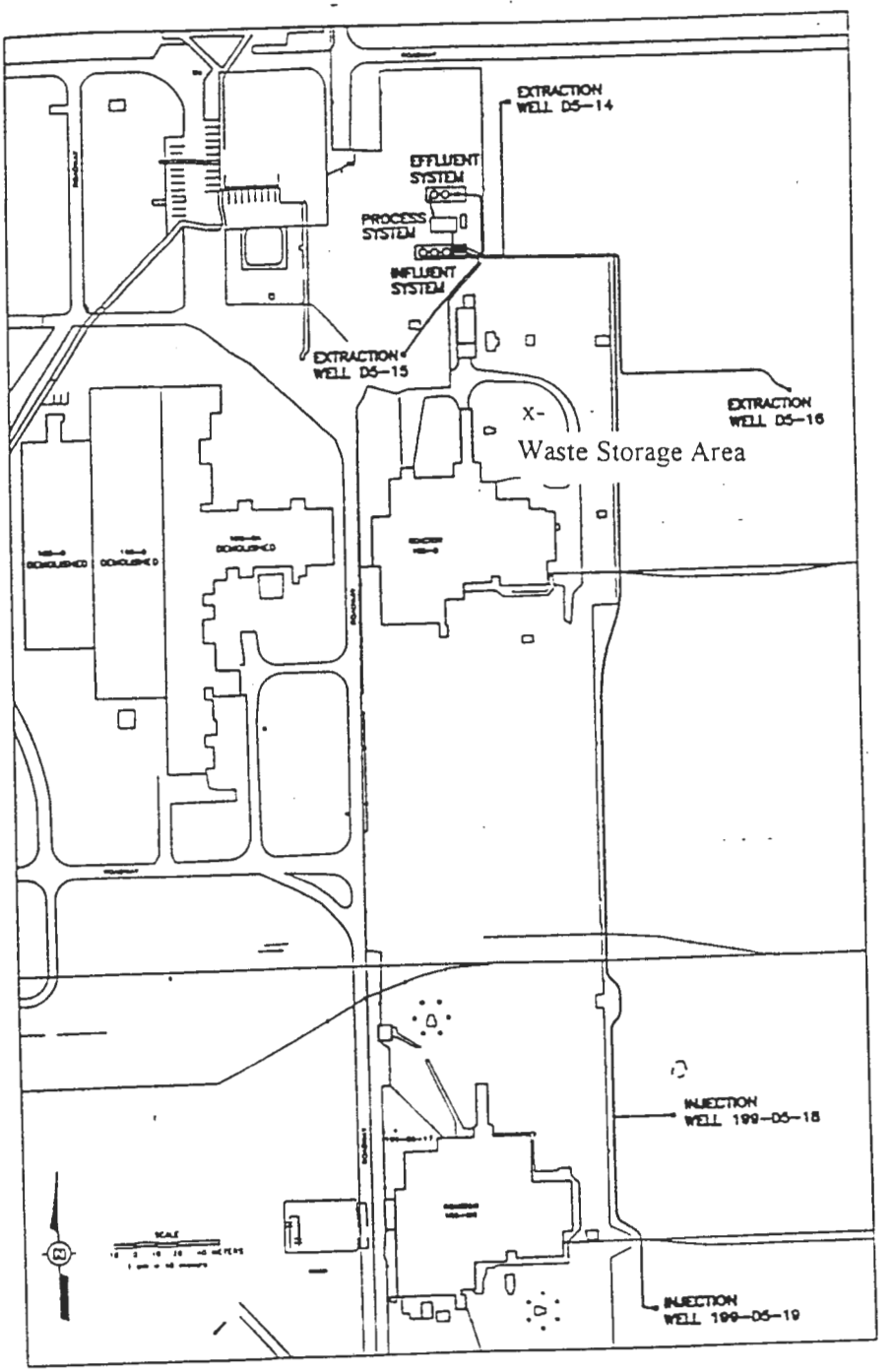
Attachment 3. Interim Control of Unknown, Suspected Hazardous, Suspected Mixed and Radioactive Waste.

____ Unknown ____ Radioactive ____ Waste Pending Analysis ____ Suspected Hazardous ____ Suspected Mixed		Unique Drum Number	Drum Type/Size	Liner Type/Thickness
Project Name/Project Location		___ CERCLA ___ RCRA-PP ___ Other _____	Well/Borehole/Excavation Number	
Footage	____ Perched Water ____ Vandose Zone ____ Water Table	Beginning Date	Date Sealed	Drum Storage Location
Contents/Inventory: (Percent of Each)		Absorbent Added: ___ Yes ___ No Container is ____ % Full		
____ Soil ____ Hardtool Slurries ____ Groundwater Slurries	____ Decon Fluid ____ Plastic ____ Tape	____ Cloth ____ Rubber ____ Paper	____ Other (specify)	
Comments/Suspected Hazard: (Any indications of contamination ORGANIC, INORGANIC, RADIOACTIVE, must be documented in this space.)				

Field Team Leader (printed name/signature) Date

Facility Generator (printed name/signature) Date

Attachment 4. 100-HR-3 Pilot Scale Pump-and-Treat System Location.



ATTACHMENT

100-KR-4 DRILLING WASTE MANAGEMENT PLAN

9713506.2030

DOE/RL-96-84
Rev. 0

DOE/RL-96-65
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UC-630

Site-Specific Waste Management Instruction for the 100-KR-4 Operable Unit Drilling

Date Published
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United States
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P.O. Box 550
Richland, Washington 99352

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1.0 INTRODUCTION

This site-specific waste management instruction provides guidance for the management of waste generated as a result of groundwater well installations in the 100-KR-4 Operable Unit (OU). The well installations are necessary to implement the Remedial Action (RA) option (pump-and-treat using ion exchange) to prevent discharge of hexavalent chromium at levels above those considered protective of aquatic life in the Columbia River and riverbed sediments.

2.0 DESCRIPTION

A total of 13 wells is currently scheduled for installation in the 100-KR-4 OU in support of the RA (Figure 1); four wells will be injection wells, three wells will be monitoring wells, and six wells will be extraction wells.

3.0 PROJECTED WASTE STREAMS/FIELD SCREENING SAMPLING

Contaminant data collected during the quarterly groundwater sampling in the 100-KR-4 OU area of influence were evaluated with regard to organics. Of the six wells in the area of concern data was available for four to five quarters each. All data were nondetects except for seven isolated detections only slightly above maximum contaminant levels (MCL). Maximum concentrations of acetone (22 μg/L), benzene (10 μg/L), and methylene chloride (18 μg/L) were found in isolated wells during either the fall 1992 or spring 1993 sampling event. No organics were detected during subsequent sampling events. These contaminants are not identified as contaminants of concern for this RA. Therefore, groundwater and saturated zone sediments are generally determined not to be significantly affected by organic chemical contaminants and no additional organic sampling will be required as part of the RA.

Well 199-K-119A has a potential to encounter radioactivity. As a precautionary measure, soil cuttings will be surveyed for radioactivity during drilling to determine the existence of radioactivity. Measurements will be made by a Radiological Control Technician using hand-held screening instruments. If radioactivity is detected in the soils, it will be contained. All other wells are not anticipated to encounter radioactivity, however as a precaution these soils that are not contained will be screened each day during drilling that soil is added to the pile.

Based on existing groundwater data, slightly elevated levels of chromium and nitrate are anticipated in slurries generated from the groundwater elevation. Moist soil samples (i.e., soil generated from the aquifer) will be periodically tested for hexavalent chromium and nitrate. Filtered groundwater will be tested for contaminants when the wells first reach the water table. Samples will be analyzed for hexavalent chromium and nitrate to verify contamination levels.

The groundwater or purgewater generated during well drilling that exceeds discharge criteria (i.e., 80 μg/L hexavalent chromium Model Toxics Control Act [MTCA] Method B [WAC 173-340], or 45,000 μg/L nitrates maximum contaminant level [MCL]) will be contained. Contained water will be processed at the 100-KR-4 treatment system, if feasible. If not feasible, water will continue to be managed at the Hanford Site purge water tanks. Water that does not exceed these criteria will be disposed on the ground surface. Field screening sample data will be generated that meet the requirements specified in the *Federal Facility Agreement and Consent Order*, Section 6.5, Quality Assurance (DOE-RL, 1995).

Because historical analytical data exist for locales where the wells will be installed, laboratory soil or groundwater analyses for chemical and radiological characterization will not be performed during the drilling activity. Soils are not anticipated to contain concentrations that exceed the MTCA B cleanup criteria of 8 mg/kg (ppm) for hexavalent chromium or 2.56 E+03 mg/kg (ppm) for nitrates. Soils are also not anticipated to contain concentrations that exceed the Hanford Site background value of 18.5 mg/kg (ppm) for total chromium. The total chromium background value is higher than the cleanup criteria of 10 mg/kg (ppm) determined by multiplying the MCL value of 0.10 mg/l (ppm) by 100. In addition, the toxicity characteristic leaching procedure (TCLP) level for hazardous/dangerous waste designation (5 ppm) is not expected to be exceeded. Therefore, soil cuttings will be returned to the ground at the drill pad. Other than that noted above, no other constituents have been identified that would result in designation of the soils as radioactive, characteristic, or dangerous waste.

Miscellaneous trash items (e.g., rags, wipes, disposable personal protective equipment) will not be dangerous waste and will be disposed of as solid waste. Should radiological or chemical contamination be encountered, this contaminated trash would be contained and disposed of appropriately. This situation is not expected.

4.0 WASTE DESIGNATION

A formal waste designation will be proposed for any waste required to be containerized due to exceedance of regulatory limits. Waste generated will be certified in accordance with the ERDF waste acceptance criteria (WAC).

5.0 WASTE SEPARATION AND SEGREGATION

All waste shall be separated and segregated as follows:

- Mixed waste debris versus mixed waste
- Mixed waste debris versus dangerous waste debris
- Dangerous waste debris versus dangerous waste

- Land disposal restriction (LDR) waste versus mixed or non-LDR dangerous waste
- Radioactive waste versus nonradioactive waste
- Mixed waste versus radioactive waste
- Dangerous waste versus nonregulated waste
- Large noncompactible debris waste versus waste soils.

6.0 PACKAGING

Dry (vadose zone) uncontaminated soils will be accumulated in piles near the point of generation and placed on the drill pad. If the moist soils must be contained, the soils will be placed on plastic and allowed to drain. Any residual, free groundwater will be collected to prevent release to the soil. This will allow soils to meet applicable waste acceptance or disposal criteria. Groundwater draining from spoil piles will be contained as described below.

Contaminated soils above criteria specified above will be contained and packaged as required to meet the ERDF WAC (BHI, 1996). This may require additional handling or stabilization, instead of the dewatering technique as described above to meet ERDF WAC. The remaining solids may be disposed of at ERDF with other 100-KR-4 OU waste identified in the 100-HR-3 and 100-KR-4 OUs Record of Decision.

Groundwater contaminated above discharge limits generated during well drilling will be contained in a portable tank and will subsequently be placed in a U.S. Department of Transportation approved drum.

Containment of decontamination rinsate will not be required, provided that downhole tools and equipment are wiped down to remove residual material prior to steam cleaning. The wiping must be sufficient to remove any solid contaminants that could conceivably show up in the rinsate. All decontamination by steam cleaning will use potable water only (with no additives).

Contaminated groundwater or soil will be contained, when required, in steel, 209-L (55-gal) open-head drums. Drums are to be no more than 80 percent full. Any water generated during waste preparation will be stored and then processed through the 100-KR-4 RA pump-and-treat system when the system is operating.

7.0 MARKING AND LABELING

The following information is to be written on the lid with indelible contrasting ink and maintained in legible condition until the Interim Control (IC) form is attached to the container:

- Project name
- Borehole number
- Footage (enter footage intervals)
- Contents (enter contents of container)
- Date sealed
- Unique container number.

The unique container number will be maintained in legible condition on the container lid from initial sealing of the container through disposal of the container contents. Unique container number legibility will be assessed during routine waste storage site inspection and maintained as required.

After making a copy, the completed plastic IC Form (Figure 2) will be secured to the side of the container. The completed IC Form provides pertinent container specific information. The copy of the completed IC Form will be sent to Environmental Restoration Waste Management for inventory tracking purposes.

8.0 TRANSPORTATION

Any waste transported offsite will be in accordance with appropriate requirements in 49 CFR 171 through 173, and DOE Order 1540.1.

9.0 STORAGE/INSPECTION

Containers of groundwater or contaminated soil/slurry may be staged in temporary, well-specific storage locales, near the point of generation, during active drilling operations. Containers will be elevated on pallets within storage areas. Following active drilling operations, containers will be consolidated into a single storage site established near the 100-KR-4 pump-and-treat site (Figure 1). Containers with free liquid (i.e., groundwater or saturated soils) to be stored outside during cold (freezing) weather will be overpacked (preferably using 361-L [95-gal] reusable poly overpacks). The unique container number of the drum will be displayed on the overpack for container identification purposes. Containers will be routinely inspected.

10.0 TRACKING/TRACEABILITY

All containerized waste shall be tracked from the point of generation until disposed.

11.0 TREATMENT TECHNOLOGY

Groundwater should be the only waste generated requiring extended management. All groundwater that is containerized will be processed at a future date through the 100-KR-4 RA pump-and-treat system. Uncontaminated soil piles will either be leveled on the well pad following well installation or removed to the 116-K-2 Trench area and spread there.

12.0 REFERENCES

49 CFR 171 to 173, 1996, "U.S. Department of Transportation," *Code of Federal Regulations*, as amended.

BHI, 1996, *Environmental Restoration Disposal Facility Waste Acceptance Criteria*, BHI-00139, Rev. 2, Bechtel Hanford, Inc., Richland, Washington.

DOE Order 1540.1, *Materials Transportation and Traffic Management*, U.S. Department of Energy, Washington, D.C.

DOE-RL, EPA, Ecology, 1995, *Hanford Federal Facility Agreement and Consent Order*, U.S. Department of Energy, Richland, Washington, U.S. Environmental Protection Agency, Region X, Seattle, Washington, and Washington State Department of Ecology, Olympia, Washington.

WAC 173-340, 1992, "Model Toxics Control Action Cleanup Regulation," *Washington Administrative Code*, as amended.

Figure 1. 100-K Area Estimated New Well Locations and Pump and Treat System Location

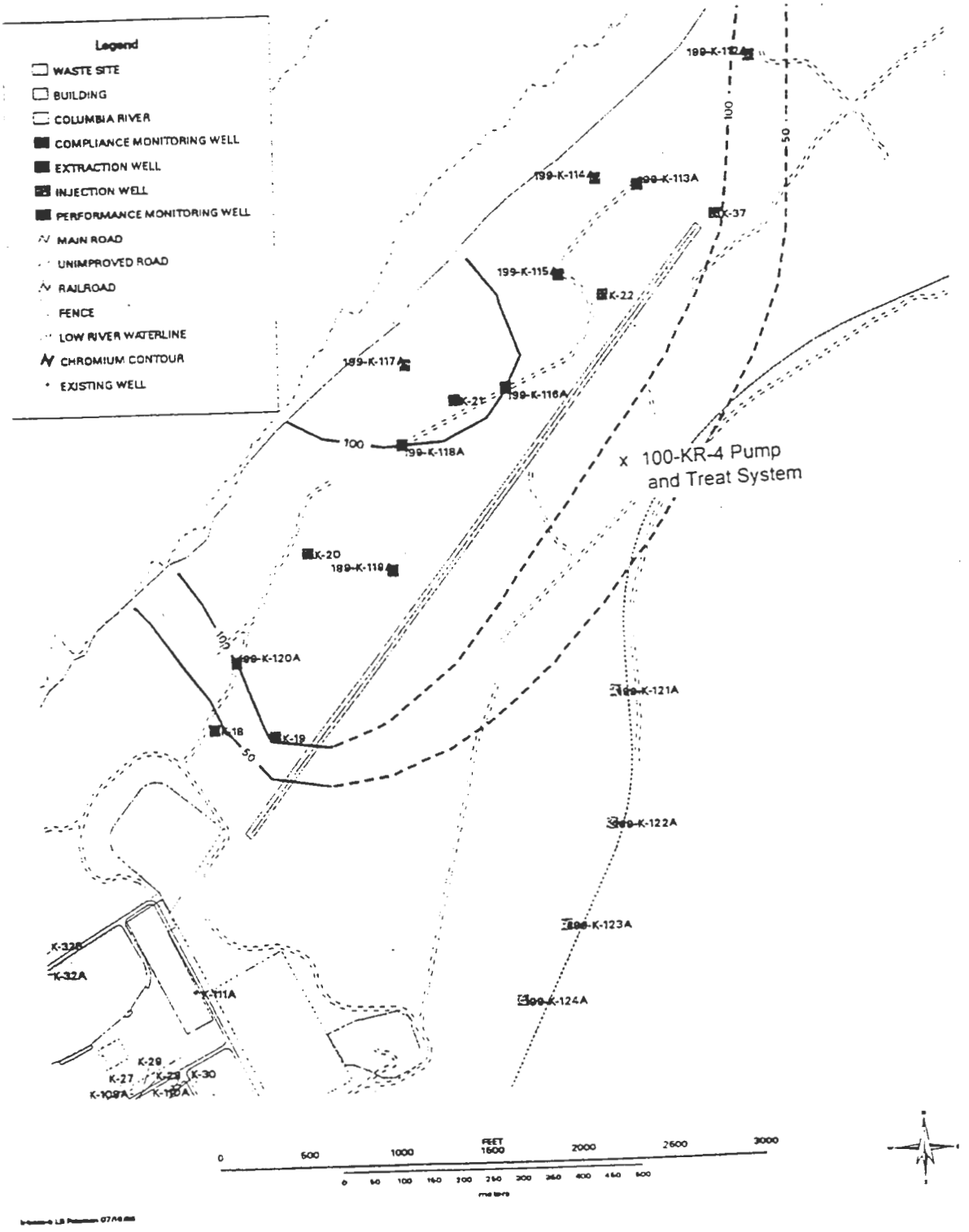

Figure 2. Interim Control of Unknown, Suspected Hazardous, Suspected Mixed and Radioactive Waste

_____ Unknown _____ Radioactive _____ Waste Pending Analysis _____ Suspected Hazardous _____ Suspected Mixed		Unique Drum Number	Drum Type/Size	Liner Type/Thickness
Project Name/Project Location		___ CERCLA ___ RCRA-PP ___ Other _____	Well/Borehole/Excavation Number	
Footage	_____ Perched Water _____ Vandose Zone _____ Water Table	Beginning Date	Date Sealed	Drum Storage Location
Contents/Inventory: (Percent of Each)		Absorbent Added: ___ Yes ___ No Container is _____ % Full		

_____ Soil _____ Decon Fluid _____ Cloth _____ Other (specify)

_____ Hardtool Slurries _____ Plastic _____ Rubber

_____ Groundwater Slurries _____ Tape _____ Paper

Comments/Suspected Hazard: (Any indications of contamination ORGANIC, INORGANIC, RADIOACTIVE, must be documented in this space.)

Field Team Leader (printed name/signature) Date

Facility Generator (printed name/signature) Date

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